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MICHIGAN STATE UNIVERSITY

AGRICULTURAL EXPERIMENT STATION

EAST LANSING

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THE QUARTERLY BULLETIN

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MICHIGAN STATE UNIVERSITY
AGRICULTURAL EXPERIMENT STATION
EAST LANSING

L. M. TURK, DIRECTOR
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GROWTH OF DOMINANT AND CODOMINANT SCOTCH PINE CROP TREES FOLLOWING THINNING[1]

By VICTOR J. RUDOLPH and WALTER A. LEMMIEN
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SCOTCH PINE *(Pinus sylvestris L.)* is a naturalized species which has been planted fairly widely in Michigan and elsewhere in the United States. Many stands have now developed to the stage where thinnings and other cultural treatments are in order. Also, it is quite likely that some of the extensive recent and current plantings of this species intended for Christmas trees will not be harvested as Christmas trees; they will grow on into pulpwood size and larger material. Such stands will need cultural treatment in the future, if they are to produce material beyond pulpwood quality.

In selecting crop trees to be favored in thinning or in pruning, the larger, more heavily-branched dominant trees in a plantation may be chosen, or the somewhat smaller, less heavily-branched codominant trees may be selected as crop trees. In making a thinning, removing dominant trees with diameters larger than those of codominants requires cutting fewer trees and the expenditure of fewer manhours per cord of cut wood. These considerations may be important in determining whether or not the thinning operation will pay for itself. Pruning codominant trees is easier and faster than pruning dominant trees, because the branches removed are generally much smaller on the codominants.

How does Scotch pine respond to thinning? Do crop trees selected from the codominant crown class develop as well as those chosen from the dominant crown class? Do codominants make good crop trees, or should only dominants be selected for crop trees in applying

[1]The authors acknowledge the assistance of Dr. P. A. Herbert, formerly of the Department of Forestry, Michigan State University, under whose direction this study by the junior author was initiated.

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thinnings? Partial answers to these questions are provided by a 7-year study in a Scotch pine plantation at the W. K. Kellogg Forest near Battle Creek, Michigan.

Description of the Plantation

The 10-acre plantation was established on a fairly level area of Fox sandy loam soil, which is a well-drained, important agricultural soil of the region. Grain and hay crops were grown on the area until 1931. White pine had been planted in the fall of 1931, and the spring of 1932, but by 1935, only a few trees had survived. The Scotch pine was shovel-planted in April, 1935 in scalps spaced 6 by 6 feet. The stock was 2-year seedlings, of excellent quality, grown from seed from Madgeburg, Germany.

Thinning Treatments Applied

In 1948, when the Scotch pine was 13 years old, the trees in the main stand were classified into dominant and codominant crown classes, and numbered with metal tags. The following spring, each of the following treatments was applied at random to five plots:

1. Thinned, leaving dominant trees as selected crop trees.
2. Thinned, leaving codominant trees as selected crop trees.
3. Unthinned control plots, in which the dominant and codominant trees were identified and numbered.

All crop trees on the thinned plots were released so that they had ample room for subsequent growth. The basal area was reduced from an average of 86 square feet to approximately 65 square feet per acre.

Results

The trees were remeasured in the fall of 1956. Data on the residual stand immediately after thinning, and in 1956, six growing seasons after thinning, are listed in Table 1.

Growth in diameter and height of dominant and codominant trees on the treated and control plots was compared between treatments and between crown classes and analyzed for statistical significance.

There were statistically significant differences at the 5 percent level in diameter growth of crop trees between crown classes and between treatments. Dominant trees in the thinned areas grew signifi-

TABLE 1—Data for dominant and codominant Scotch pine crop trees

Treatment	Average D. B. H.		Growth in D.B.H. 1949 to 1956	Average total height		Growth in height 1949 to 1956	Average length of live crown 1956
	1949	1956		1949	1956		
	in.	in.	in.	ft.	ft.	ft.	percent
Thinned-							
Dominant crop trees.....	5.4	6.9	1.5	29.4	44.7	15.3	25
Codominant crop trees.....	4.3	5.3	1.0	26.6	40.6	14.0	23
Unthinned (control)-							
Dominant crop trees.....	5.4	6.6	1.2	29.4	45.0	15.6	26
Codominant crop trees.....	4.2	4.9	.7	27.4	42.0	14.6	19

cantly more in diameter than dominant trees in the control areas. Dominant trees favored by thinning grew more in diameter than codominant trees in both thinned and unthinned areas. In the control areas, diameter growth of dominant trees was significantly greater than that of the codominant trees. Codominant crop trees in the thinned areas grew significantly more in diameter than codominant trees in the control areas, but not quite as much as the dominant trees in the control areas.

Differences in height growth between crown classes were also statistically significant at the 5 percent level. Height growth of dominant trees in thinned and unthinned treatments was significantly greater than that of codominant crop trees in both treatments. However, the height growth of dominant trees was about equal on thinned and unthinned areas.

Table 1 also lists the average length of live crown expressed as a percent of total tree height. The codominant trees on the unthinned areas had a significantly shorter live crown length than that of trees on the other areas. The effect of this short live crown length on reducing diameter growth is very apparent.

Summary

Diameter and height growth of 21-year old dominant and codominant Scotch pine crop trees in a plantation were analyzed in 1956, six growing seasons after thinning treatment. Thinning significantly increased the diameter growth of both dominant and codominant crop trees. Codominant crop trees left after thinning made greater diameter growth than codominant crop trees without thinning, but in general, they did not equal the diameter growth of dominant crop trees left after thinning.

Height growth of dominant trees was not affected by thinning. Height growth of dominant trees was generally greater than that of codominant trees, except that after thinning, height growth of codominants was substantially as fast as that of dominants.

When early thinnings are made in Scotch pine plantations of pulpwood size, crop trees should in general be selected from among the dominant trees. However, well-formed codominants may be left as acceptable crop trees. They are easier to prune because of smaller branch size, and their boles have smaller swellings at the branch whorls than the boles of dominants. Their subsequent growth is greater than that of codominant trees which have not been thinned, and about equal to that of dominants which have not been favored by thinning.

LONG TERM EFFECTS OF PHOSPHATE AND POTASH APPLICATIONS TO ORGANIC SOILS:

I. CARROTS, POTATOES AND TABLE BEETS

By J. F. DAVIS, L. N. SHEPHERD, and R. E. LUCAS

DEPARTMENT OF SOIL SCIENCE

Introduction

VARIED YIELD RESPONSES of crops growing on organic soils to applications of fertilizers have long been recognized. Climate, crops, soil test and varieties of crops are among the factors associated with these observed differences. Crops and residual soil fertilizers are the principal bases used for recommendations of the major plant nutrients (nitrogen, phosphorus and potassium) that appear in a Michigan State University Cooperative Extension Service bulletin.[1]

Data collected over a 17-year period (1941-1957) demonstrate some of the variable effects obtained during this time.

Procedure

An experiment was set up in 1941 on a virgin Houghton muck. This soil has a pH of approximately 6.4, contains 80 percent organic matter (ignition method) and has an exchange capacity of 182 milliequivalents per 100 grams. Nine treatments and an unfertilized check were included in the experiment. These treatments consisted of two different levels of phosphate and potash identified as low and high fertility series. The treatment combinations for the low level were 100-50, 50-50, 50-100, 50-150, 0-150, 25-150, 75-150, 50-200, and 100-0 pounds of phosphate and potash, respectively. The amount of phosphate and potash was doubled on the plots of the high fertility series.

[1]Michigan State University Cooperative Extension Bulletin 159, Fertilizer recommendations for Michigan crops, 1954.

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There were 5 replications of the first 4 treatments, 2 unfertilized checks and 1 plot each of the other combinations of phosphate and potash.

In 1955, a change was made in the fertilizer treatments in that 25 pounds of nitrogen was applied on the low fertility area with the exception of the check plots and 50 pounds of nitrogen on the high fertility series as a pre-plant application. Minor elements were supplied as needed.

The fertilizers were applied with the fertilizer attachment of a grain drill and placed 3 to 4 inches deep prior to the planting operations.

The area of each treated plot was 30 x 200 feet. One-half of the area received the high rate of fertilizer and the other half the low rate. These plots were in an east to west direction and the crops were planted across the plots in a north to south direction. Standard cultural practices such as date of planting, spraying operations, etc. were employed. Several crops were grown each year.

Soil tests have been taken at various times and the tests of 1957 are reported in Table 2. The Spurway active test (1:8 soil-extractant dilution) utilizing .018 normal acetic acid as the extractant was used.

The effect of these treatments on carrots, table beets, and potatoes is reported.

Results and Discussion

The data in Table 1 show the effect of various combinations of phosphate and potash on the yield of Chantenay carrots. There was a wide variation in yield per acre during the 5 years that carrots were grown, e.g. the yield in 1948 was more than double the yield in 1947. The degree of response to potassium was variable with probably the greatest response occurring in 1954. The yield of the plot receiving 150 and 300 pounds of phosphate and potash was adversely affected in 1954 by a severe nematode infestation.

Yield from the plot receiving phosphate alone, in each of the 5 years, was lower than the average of the 2 plots where no fertilizer was applied.

These data indicate that, on the average, on plots where 50 pounds of phosphate and 300 pounds of potash are applied annually, top yields of carrots will result.

The response to phosphate by the carrot crop is much lower than

the response to potash as indicated by the relatively high yield of the plot where potash alone (0-300) had been used.

Data in Table 2 show the effect of phosphate and potash applications on the yield of table beets. Detroit Dark Red beets were grown on both the "high" and "low" fertility level series in 1957. Yields in 1947 were low because of the early summer planting.

On the average, table beets were extremely responsive to potash applications. Potash in the amount of 150 pounds per acre applied annually was apparently sufficient to give near maximum yields.

Table beets vary from potatoes and carrots in that the response to potash alone in the absence of phosphate was much less than with the other two crops mentioned.

One of the advantages of the fertilizer in the production of table beets is that it tends to reduce the amount of black root.

Data in Table 3 show the effect of the different amounts of phosphate and potash on the yield of potatoes. The response was very similar to that obtained with carrots. There was a considerable variation in yields and in response to potash between years suggesting a marked effect of climate. This inference regarding climate is based in part on the fact that good cultural practices were employed in the various experiments thus eliminating cultural practices as a practical explanation of yearly variation.

TABLE 1—The effect of rates of application of phosphate and potash on the yield of Chantenay carrots

Pounds per acre		Tons per acre					
P_2O_5	K_2O	1947	1948	1950	1953	1954	Average
200	100	14.6	34.6	23.7	28.4	19.3	24.1
100	100	14.3	34.1	23.0	27.7	22.6	24.3
100	200	15.1	35.3	25.0	32.4	25.5	26.7
100	300	15.7	36.7	25.8	29.8	27.3	27.1
L.S.D. (5% level)		(*a*)1.0	2.7	1.9	4.8	3.5	
0	300	12.9	26.5	19.0	27.2	17.9	20.7
50	300	17.4	32.4	27.3	34.4	22.3	26.8
150	300	16.9	33.9	26.3	36.5	14.9(*b*)	25.7
100	400	17.9	33.9	24.6	34.6	25.0	27.2
200	0	2.4	16.6	8.0	10.9	7.1	9.0
No fertilizer		3.6	19.4	8.4	13.0	8.6	10.6

(*a*) Refers to data from first 4 treatments only.
(*b*) Severe nematode infestation.

TABLE 2—The effect of application of phosphate and potash on the yield of Detroit Dark Red table beets and soil tests

Pounds per acre		Tons per acre				Soil test(*a*)	
P_2O_5	K_2O	1947	1949	1957	Average	P	K
200	100	5.2	14.9	16.5	12.5	18	28
100	100	4.8	15.3	14.5	11.5	8	28
100	200	6.3	17.0	18.5	13.9	9	65
100	300	7.0	21.6	17.7	15.4	12	182
(*b*)L.S.D. (5% level)		0.4		2.9			
0	300	3.7		1.8		3	178
50	300	6.4		17.6		7	220
150	300	7.3		18.2		26	220
100	400	7.3		16.5		7	220
200	0	0.4		5.7		20	21
No fertilizer		0.4		2.6		5	18
100	50			10.4		11	14
50	50			9.2		5	16
50	100			13.1		5	41
50	150			18.3		7	95
(*b*)L.S.D. (5% level)				3.9			
0	150			4.2		5	103
25	150			17.6		1	62
75	150			22.9		6	41
50	200			20.5		5	89
100	0			2.3		10	7
No fertilizer				2.9		3	7

(*a*) .018 N acetic acid extractant (1:8 soil-extractant ratio).
(*b*) L.S.D. values refer to preceding 4 treatment means in the column. Data not available for blank spaces.

TABLE 3—The effect of rates of application of phosphate and potash on the yield of potatoes

Pounds per acre		Bushels per acre								
P_2O_5	K_2O	1947	1948	1949	1950	1951	1952	1953	1955	Average
200	100	568	459	436	355	329	313	391	218	384
100	100	602	450	435	378	344	377	401	238	403
100	200	653	477	507	553	400	456	495	296	480
100	300	695	483	518	573	450	454	545	293	501
L.S.D. (5% level)		55	N.S.	74	44	45	67	89	60	
0	300	547	270	375	290	221	258	375	170	313
50	300	730	418	564	614	539	404	548	359	522
150	300	742	541	545	569	552	427	497	327	525
100	400	695	445	547	556	511	422	546	255	497
200	0	89	177	43	53	126	49	81	38	82
No fertilizer		113	171	91	56	72	83	78	40	88
Variety:		AFY-4	White Warba	Sebago	Sebago	Sebago	Sebago	Sebago	Sebago	

According to the data, optimum rates of phosphate and potash for top potato yields were 50 pounds and 300 pounds per acre, respectively. Increasing the amount of potash to 400 pounds per acre did not increase the potato yields over those obtained where 300 pounds were applied. Yields from plots where phosphate alone was applied were on the average similar to those obtained from unfertilized areas. Observations generally show potassium deficiency symptoms of most crops are more intense on plots where phosphate alone has been applied than on the unfertilized areas.

An interaction was observed in 1951 between two varieties of potatoes, Sebago and Katahdin. As noted in Table 3, a significant response to 300 pounds of potash per acre was obtained with the Sebago variety. Unreported data from the same experiment showed that no additional yield of the Katahdin variety was obtained where more than 100 pounds of potash was applied. The Katahdin potato is a slightly earlier maturing variety than the Sebago.

As the amount of potash applied is increased, there is a tendency for a potato with lower starch content to be produced as shown by the data reported by Lucas et al, 1954.[2] Fertilizer with a 1-3 phosphate-potash ratio produced the highest yield of potatoes but the potatoes contained 2 percent less starch than did those fertilized with a 2-1, 1-1 or a 1-2 ratio. However, the color of the tubers, as indicated by the alcohol test, was as good or better where the 1-3 ratio was applied than where other ratios were used.

Soil test data (Table 2) taken in the spring of 1957, show that the tests reflected the amount of nutrients applied and to a lesser degree the extent of crop removal. In all cases there has been a build-up in residual phosphorus and potassium in the soil. Tests for phosphorus where 200 pounds of phosphate per acre was applied annually were approximately double those from areas receiving 100 pounds. A similar relationship existed for potassium applications. Phosphorus tests continued to increase with the highest rate of application. This was not the case with potassium in that increasing the application of potash to 400 pounds per acre annually did not result in a correspondingly higher potassium soil test.

It is evident that comparable yields of crops may be obtained from plots with widely different phosphorus-potassium residual levels providing adequate amounts of phosphate and potash are used.

[2]Lucas, R. E., E. J. Wheeler, and J. F. Davis, 1954. Effects of potassium carriers and phosphate-potash ratios on the yield and quality of potatoes grown in organic soils. Am. Potato Jour. 31: 349-352.

Summary and Conclusions

The long term effects of a phosphate-potash ratio experiment initiated in 1941 on Houghton muck on the yield of carrots, table beets, and potatoes may be summarized as follows:

1) Wide annual variations between yields of crops and degree of potash response occurred with the three crops.

2) Crops on this organic soil responded more to potassium than to phosphorus fertilization.

3) The response of table beets to applied phosphate was greater than that of either carrots or potatoes.

4) The application of phosphate alone tends to reduce yields below the unfertilized areas and intensifies potash deficiency symptoms in the plant.

5) Soil tests using 0.018 N acetic acid extractant (1:8 soil-extractant dilution) reflect the amounts of plant food applied and to a lesser extent crop removal.

6) Comparable yields of crops may be obtained on soils varying widely in soil test levels providing adequate amounts of phosphate and potash are applied annually.

7) Yearly variation in yield and degree of response suggest the need for a detailed climatic-yield response study.

THE USE OF A RECORDING RESISTANCE BRIDGE IN SOIL MOISTURE STUDIES

By L. H. STOLZY, G. A. CRABB, Jr. and A. E. ERICKSON

Department of Soil Science

SUMMARY

A LEEDS AND NORTHRUP MICROMAX was used with Bouyoucos plaster of paris blocks to automatically record changes in resistance in soil moisture blocks. The Micromax was used to balance an A. C. operated Wheatstone bridge. As the slide wire rotated to balance the bridge, it also moved a multiple-point indicator along a logarithmic chart reading from 250 to 50,000 ohms. The instrument required 15 minutes to record the resistance values of 16 moisture blocks.

This study was conducted at the Michigan Hydrologic Research Project, East Lansing, Michigan. Soil moisture blocks were buried at different depths in the soil profile under alfalfa, oats and blue grass. The soil moisture data were correlated with rainfall and runoff data collected at the project. An analysis of the data showed the transmission rates and infiltration capacity based on rainfall and runoff to be much greater for the soil profiles under alfalfa and grass than for the soil profile under oats.

INTRODUCTION

The collection of hydrologic data in watershed studies has, in many aspects, lent itself to automation techniques. However, soil moisture studies present certain problems regardless of whether they are made manually or automatically. Recording tensiometers were used by Schiff (1949b) to measure changes in soil moisture conditions in hydrologic studies. A six-point multiple recording potentiometer connected with an ohmmeter circuit was used by Korty and Kohnke (1953) to measure changes in resistance values of nylon blocks. The

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same general type of study as Korty and Kohnke made was also made at the Hydrologic Station in East Lansing (1949). In this study a Leeds and Northrup Micromax was used with plaster of paris and nylon blocks to record changes in resistance of soil moisture units. The main difference between the method used by Korty and Kohnke and the one used in Michigan was in the circuitry of the two instruments. Theirs was a potentiometer ohmmeter circuit; the one in Michigan was an automatically operated Wheatstone bridge powered by a 110-volt, 60-cycle current.

EXPERIMENTAL PROCEDURE

This study was made on the watersheds of the Michigan Hydrologic Research Project during the spring and summer of 1949. The details of this station were reported by Garstka (1944). Changes in resistance of soil moisture blocks were recorded in three different areas under three types of soil covers. One watershed had a second-year alfalfa cover; the other had been planted to corn for two years and during the spring of 1949 was planted to oats. The third area in which soil moisture block data were taken was in a permanent blue grass sod. One site was selected in each of these three areas about 40 feet from the instrument house. At each of these sites a battery of gypsum and nylon moisture blocks were buried in the soil profile. Bouyoucos' (1940) second method of installing moisture blocks in the soil was followed. They were buried at the following depths under alfalfa and oats: 3, 6, 12, 24, 36 and 60 inches. In the blue grass area they were buried at 6, 12, 24 and 36 inches. The ends of the block leads were located in the instrument house where the Micromax was installed.

One of the modifications in this instrument from the commercial models was the use of an alternating current in place of direct current instruments. The alternating current was necessary to prevent electrolysis and polarization in the blocks (Bouyoucos, 1940). The wiring diagram (Fig. 1) also shows a transformer used to reduce the voltage in the circuit of the resistance blocks. A further refinement in the plotting of resistance values was obtained by use of a logarithmic scale.

As the slidewire rotated to balance the bridge, it also moved a multiple-point indicator along a logarithmic chart readings from 250 to 50,000 ohms. Every 57 seconds the Micromax balanced the bridge

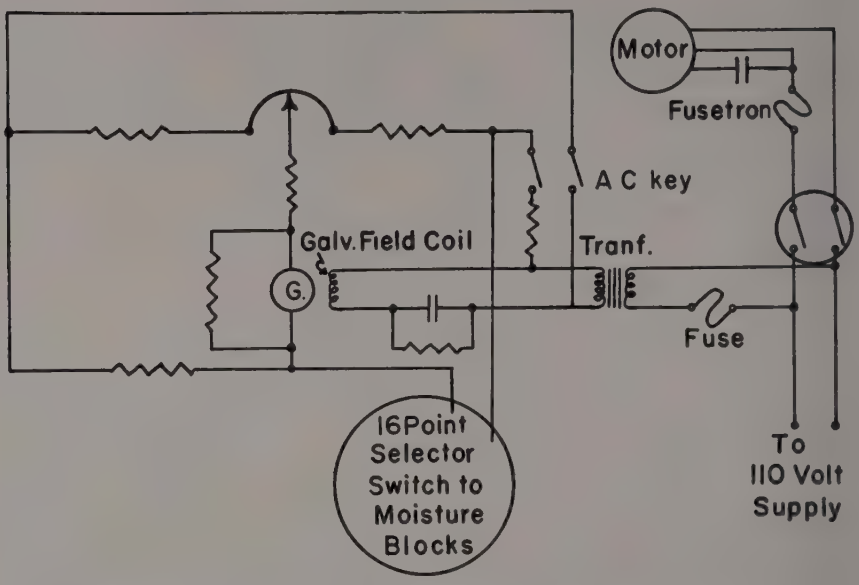

Fig. 1. Circuit diagram of the recording Wheatstone bridge.

and recorded the resistance of a block on the logarithmic chart. After each recording, the multiple-point indicator automatically switched to the next soil moisture unit until the readings for the network of 16 blocks was recorded.

Daily soil temperature measurements were taken with copper-constantan thermocouples as reported by White (1946). These temperature measurements were made at the same depth in the soil profile as the blocks were installed. The temperature values were used to correct the resistance of the moisture block to 60° F.

Other hydrologic information was collected on the areas simultaneously with this study, and measurements were made of various soil physical properties.

RESULTS

Instruments

In the original planning the circuitry of the instrument was designed to be used with the plaster of paris block. However, nylon units were in commercial production and available at the time the blocks were placed in the soil and a set of these was installed near

the plaster blocks. It was found impractical to use the two types of blocks interchangeably on this recorder due to the difference in range of the resistance readings of the two types of units.

In checking the accuracy of the recording Micromax it was found that resistances of plaster blocks were consistently higher when measured with the recorder than when measured with the Bouyoucos bridge, (Fig. 2), while with standard resistances both instruments were in close agreement. Length of block leads up to 100 feet did not change the measured resistance value on either instrument. A possible reason for this difference was the frequency of the A. C. power supply of the two instruments. The Bouyoucos bridge had a frequency of 2,000 while the Micromax had a frequency of 60.

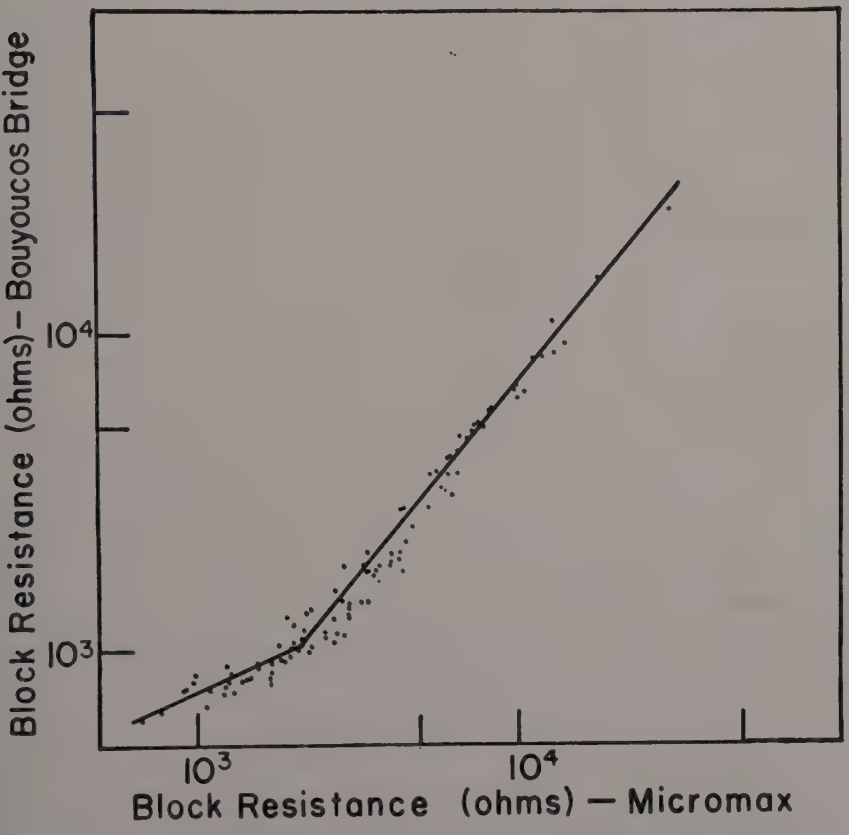

Fig. 2. Comparison between block resistance obtained with the Micromax and with the Bouyoucos bridge.

Plaster blocks — The moisture units had been in the soil for over a month before the Micromax was used to measure resistances. Starting on June 9, 1949, resistance values were taken on each of 16 plaster of paris blocks every 15 minutes. These measurements were continuously made on the blocks for over a year. It was not apparent at first that the characteristic resistances of the blocks were changing. However, this became apparent during periods of high soil moisture during the fall months.

The storm on June 13, 1949, (Fig. 3) made it possible to compare the resistance of the moisture blocks in the first foot of soil. The resistance values of these blocks, corrected to 60° F. after the storm, were within a range of resistance values from 850 to 895 ohms except for the 3- and 6-inch depths under oats. The resistance of the 3-inch block under oats had shifted the most.

In making the same type of comparison for the storm of June 29, 1949, greater differences in blocks were found (Fig. 4). In Fig. 4 a reversed linear scale was used to show clearly differences in block resistances and to accommodate rain-fall data. The low resistances of the moisture blocks under alfalfa did not change.

The other five blocks under the fibrous root system of oats and grass shifted in resistance. The block under oats, which is a vigorous

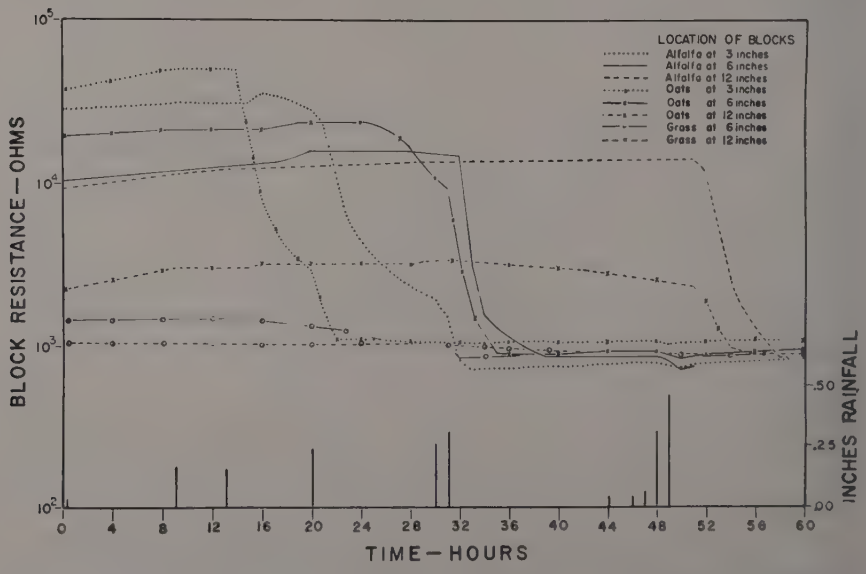

Fig. 3. Changes in block resistance for the storm beginning on June 13, 1949.

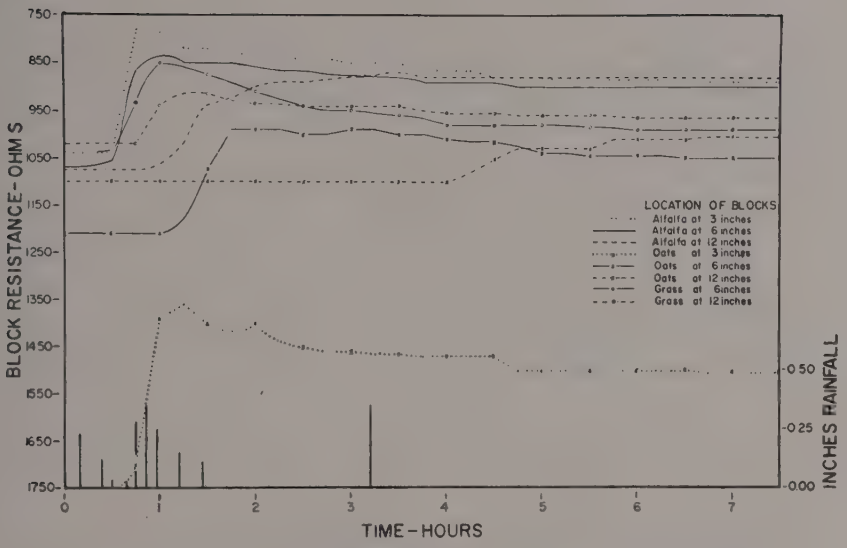

Fig. 4. Changes in block resistance for the storm of June 29, 1949.

fast growing crop at this time of year, had the greatest shift in resistance. The greatest change was in the block at the 3-inch depth and the least in the block at 12 inches. The same relationship was true for grass to a lesser extent. The 6-inch block changed the most while the 12-inch block changed the least. Changes in block resistances have been reported by other workers.

One reason for this to be more pronounced in one crop than in another may be due to the type of environment the root system creates around a moisture block. It, nevertheless, would be difficult to convert resistance values of moisture blocks to percent moisture in the soil with any accuracy. It is realized that the continual readings taken on these blocks contributed to the change in the resistance readings of the blocks. It was also evident that the type of soil cover had some effect on the block. Blocks taken from the 3-inch depth and the 36-inch depth were examined at the completion of the study. The electrodes in the block at 3 inches were pitted and coated with a copper sulfate deposit, while the block at the 36-inch depth appeared to be in good condition.

Hydrologic studies—There were only two storms during the growing season of 1949 that could be analyzed in this study. These storms were on June 13 and June 29. The one on June 13 was not of sufficient

intensity to cause runoff while the storm of June 29 had high enough intensities and amounts of rainfall to cause runoff on both watersheds under alfalfa and oats. Soils in both watersheds at the time of this storm were near field capacity. There had been 0.46 inches of rain on June 25.

Amounts of vegetation on the three areas being compared at this time were: alfalfa, 18 inches high with a dense cover; oat cover, about 24 inches high with the grain in the milk stage, and grass 10 inches high with a dense cover. From the standpoint of interception storage, the alfalfa and oats were about the same. The grass area was somewhat less. An analysis was made (Table 1) of the rainfall and runoff data for the June 29 storm.

TABLE 1—Analyses of data for the storm of June 29, 1949

Precipitation(*a*)				Water sheds			
				Alfalfa		Oats	
h	m	Amount in.	Intensity in/hr.	Runoff	Infiltration rate	Runoff	Infiltration rate
				inches	in/hr.	inches	in/hr.
14	00	.00					
14	11	.23	1.28	.00	1.28(*b*)	Trace	1.28(*b*)
14	18	.00	0.00	.00	0.00	Trace	0.00
14	24	.12	1.20	.00	1.20	Trace	1.20
14	30	.03	0.30	.00	0.30	Trace	0.30
14	40	.03	0.18	.00	0.18	.00	0.18
14	45	.28	3.36	Trace	3.36	Trace	3.36(*c*)
14	52	.35	3.00	Trace	3.00	.09	2.23(*c*)
14	58	.25	2.50	Trace	2.50	.12	1.30(*c*)
15	12	.15	0.65	Trace	0.65	.06	0.39(*c*)
15	26	.11	0.47	.00	0.47	.05	0.26
17	12	.35	0.21	.00	0.21	.00	0.21

(*a*) Previous precipitation 4 days.
(*b*) No correction for interception and depression storage.
(*c*) Infiltration capacity.

Total infiltration for any period of rainfall is the amount of water absorbed by the soil mass. This is equal to the inches of rainfall minus the inches of runoff and inches of interception storage (rain water held by the plants on their leaves and stems). The infiltration rate is sometimes limited by rainfall intensity. When the infiltration becomes a function of the soil it is then infiltration capacity.

The total rainfall for this period was 1.90 inches. Of this amount

less than 0.01 inches were lost due to runoff on the watershed with alfalfa. The initial infiltration rates on the two watersheds were about the same. However, the rainfall exceeded the infiltration capacity for the watershed under oats during the latter part of the storm. It is doubtful that the rainfall exceeded the infiltration capacity on the watershed under alfalfa.

Schiff (1949a) in his studies at Coshocton, Ohio, used the term, "transmission rate", which is the movement of water downward through a given depth within the soil mass per unit time. The opinion was that with a continuous record on soil moisture blocks, "transmission rates" for the soil under alfalfa, oats, and grass were measured by the length of time it took the plaster of paris blocks to decrease in resistance (Table 2).

The assumption was also made that "transmission rates" for the soil and the gypsum blocks were the same. All of the values are relative in that no measurements were made on resistance blocks at the soil surface. Much higher rates would be evident for alfalfa if the 3- to 6-inch depth were figured separately, while for oats if the 6- to 12-inch depth were figured separately, it would be lower than reported. Nevertheless, all "transmission rates" are high except the 6- to 12-inch depth under oats. The surface "transmission rates"

TABLE 2—Transmission rates within the soil profile under the three types of cover for the storm of June 29, 1949

Type of cover	Time blocks changed		Soil horizon considered	Transmission rate
	h	m	Inches	in/hr.(a)
Alfalfa	14	00		
	14	36	0-3	5.0
	14	41	0-6	8.8
	15	11	0-12	10.0
Oats	14	00		
	14	44	0-3	4.1
	15	16	0-6	4.8
	17	20	0-12	3.6
Grass	14	00		
	14	40	0-6	9.0
	15	00	0-12	12.0

(a) Rainfall is limiting condition.

were low due to the fact that the rainfall was not sufficient to equal the infiltration capacity of the soil until 14:40 E.S.T., at which time the rainfall intensity was 3.36 inches per hour.

The "transmission rates" for the 0- to 3-inch depth were the same for alfalfa and oats, if the time lapse between the two resistance readings were considered. This would mean that the resistance reading on the block at the 3-inch depth under alfalfa would be measured six minutes before the resistance was measured on the block at the 3-inch depth under oats. However, the water moved much faster in the soil profile under alfalfa and grass down to the 12-inch depth, while a restrictive layer was evident in the 3- to 12-inch soil horizon under oats.

The soil under the alfalfa and oats had been mapped as a loamy fine sand. Differences in the water movement in the two areas could be related to the management practices for the two watersheds. The alfalfa area had been in the following crops: 1946, corn; 1947, oats seeded to alfalfa; 1948, alfalfa; 1949, alfalfa. The oats area had been in the following crops: 1946, alfalfa; 1947, corn; 1948, corn; 1949, oats seeded to alfalfa. The two years of corn caused a breakdown of soil structure which was substantiated by soil cores taken around each set of soil blocks.

DISCUSSION

In a complete hydrologic study, information is needed on all phases concerned with the disposition of precipitation. The water infiltrating into the soil becomes an important part of the hydrologic cycle. In order to obtain more complete data on what happens to rainfall, automation techniques will have to be used to measure water movement in the soil profile. This was one attempt to combine two types of equipment into a practical unit for studying water movement. With certain refinements in the method and equipment this would be a valuable tool in studying water movement under watershed conditions.

In the report by Korty and Kohnke (1953) it was mentioned that stabilizing the ohmmeter circuit was a problem. They also mentioned that a bridge circuit to measure the resistance of the block directly may increase the accuracy of the method. The best type of recording circuit to be used on the different types of moisture units would be worth knowing when planning such a study. Both the ohmmeter

circuit and Wheatstone bridge circuit have been used successfully in the manually operated instruments.

The recording Wheatstone bridge used in this study did not give satisfactory data on the nylon units. Satisfactory results may have been obtained on the nylon units in a finer textured, slower drained soil. The relative error of the recorder on known resistances was: at 1000 ohms, 0 percent; at 4000 ohms, 2.5 percent; at 10,000 ohms, 4 percent. The fact that deterioration did take place in the plaster blocks would limit their use to short periods of measurements unless an increase in the cycling of the bridge circuit would improve this condition.

ACKNOWLEDGMENT

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COST OF MICHIGAN FRUIT STORAGE BUILDINGS AS AFFECTED BY SIZE AND TYPE OF CONSTRUCTION

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The fruit grower, or storage operator, planning a new refrigerated storage is interested in the relative costs and attributes of different types of construction. This report is the result of a study (Pflug, 1958) designed to provide some of the answers to this question, and also the question of clear-span vs posts and the economics of storage size. The relative cost of different types of foundation, wall and ceiling or roof construction for several common sizes of storage rooms will be presented and discussed.

Computation of Costs

These engineering cost estimates were made by determining the cost of each unit of the storage building. The final building cost is the sum of the unit cost values. The unit cost consists of material costs plus the product of the labor rate and the hours of labor per unit. The labor rate and materials cost used in this study were the actual prices and rates in effect in the Kent County (Michigan) area during the third and fourth quarter of 1957. The hours of labor per unit were obtained from Means (1957, '58).

The estimates in this report do not include provision for overhead or profit. To estimate the cost of a contracted storage these labor and materials costs must be increased by 26.5 percent to cover overhead and profit.

Table 1 lists the cost figures used for the more common material and labor.

[1]Present Address: Blackmer Pump Company, Grand Rapids, Michigan.

ARTICLE 41-80

TABLE 1—Costs used in estimating refrigerated fruit storage building

	Unit	Amount
Labor		
Carpenter	per hour	$3.25
Carpenter helper	per hour	2.00
Common labor	per hour	2.00
Mason	per hour	3.40
Mason helper	per hour	2.00
Materials		
Block, light weight 4 x 8 x 16"	100	$23.00
Block, light weight 8 x 8 x 16"	100	27.00
Block, light weight 12 x 8 x 16"	100	33.00
Concrete, transit mix	cu. yd.	15.00
Excavating and back-filling	cu. yd.	1.00
Insulation, board form	100 bd. ft.	12.00
Insulation, fill type	100 cu. ft.	14.00
Lumber, structural grade	1000 bd. ft.	160.00
Roof, flat 20 year pitch and gravel	100 sq. ft.	22.00
Steel, concrete reinforcing	per ton, in place	250.00
Steel, WF beams	per ton, erected	400.00
Tile, vitrified, salt glazed 4 x 5 x 12"	100	19.00

Foundation and Floor Cost

Table 2 lists estimated costs (in dollars per 100 lineal feet of foundation) for excavating and back filling, footings, and foundation wall. The estimated cost for both poured (monolithic) and concrete blocks filled with concrete has been included. Monolithic concrete is approximately two times the cost of a concrete block wall filled with concrete, even when form lumber can be re-used. The difference in cost is in the large amount of labor necessary to make, erect and remove the forms for the poured concrete foundation wall.

Table 3 lists the cost per 100 sq. ft. for constructing nominal 4- and 6-inch concrete floors. In standard practice, when a 4-inch floor is specified, a 2 x 4 (1⅝ x 3⅝) is set edgewise and used to level the concrete fill, and a 2 x 6 (1⅝ x 5½) is used for a nominal 6-inch floor.

No floor insulation cost has been included since it is standard practice in Michigan to omit floor insulation and use only perimeter insulation. The cost of perimeter insulation 2 inches thick and 24 inches high is 40¢ per foot of foundation wall. All storage buildings should have a smooth, level floor for mechanical or hand fork-truck operation.

TABLE 2—Estimated cost of footing and foundation wall for fruit storage building

Construction operation	Cost ($ per 100 lineal feet)
Excavating and back filling	$44.50
Footing 12" x 24", 2⅝ inch reinforcing rods	292.50
Foundation wall (12 inch wide, 48 inch high, for shorter walls reduce estimate by percent reductions in height.)	
Monolithic concrete	904.00
Monolithic concrete form lumber reused	728.00
Concrete block wall, 12 inch blocks filled with concrete	392.50
Foundation wall (16 inch wide, 48 inch high, for shorter walls reduce estimate by percent reduction in height.)	
Monolithic concrete	997.00
Monolithic concrete form lumber reused	821.00
Concrete block wall, 8 inch blocks filled with concrete	542.50

Cost of Comparative Types of Wall Construction

In estimating the cost of the walls, it was assumed that the wall would be 20 feet high and would start at the top of the foundation (floor level). Costs were calculated on the basis of 100 sq. ft. of wall surface. Where single wall, concrete block construction was used, allowance was made for pilasters, wall reinforcement ties and sealing or painting. In the tile and block cavity wall, wall ties were included in the cost estimate. The cost of the recommended (ACR Data

TABLE 3—Cost of concrete floor in fruit storage building

Type of Construction	Cost ($/100 sq. ft.)
4 inch concrete floor with 6 x 6 mesh.	27.50
6 inch concrete floor with 6 x 6 mesh.	40.00

Book 1957) insulation for a 32°F. refrigerator of 4 inches of board form insulation, or its equivalent, was included as part of the wall estimate. If a board form insulation was used with single wall construction, provision was made for a surface wearing coat of either plaster or suitable mastic.

The cost of the three common types of walls are presented in Table 4. Cross sections of the 3 walls showing construction are illustrated in Fig. 1. Three values — $126 per 100 sq. ft. for a lightweight block wall with 4 inches of board form insulation compared to $154 for a double tile cavity wall with fill insulation and $119 for a double block wall with fill insulation—do not tell the whole story. The cost of maintaining the building after construction has not been considered and this will be considerably higher for a concrete block type of building than for a glazed tile building.

The cost of tile was estimated at $190 per thousand (Table 1); this represents a good grade of tile. By reducing the quality of the tile used in the wall, the cost can be reduced; however, one of the advantages of tile construction is its permanence, and this is lost to a certain degree when lower quality materials are used.

The total wall cost, or the wall cost per sq. ft. of storage, decreases as the size of the storage increases and as the geometry of the storage approaches a square. The length of wall is 2 (L+W), the area is L×W. This relationship can be illustrated by 3 examples: A

TABLE 4—Wall cost per 100 square feet for fruit storage building

Type of construction*	Cost ($ per 100 sq. ft.)
Lightweight type 8 inch concrete block wall with necessary pilasters plus 4 inches of board form insulation protected by an inside plaster or mastic surface plus sealing outside	126.00
Double tile cavity wall with 6 inches of fill-type insulation. (5 inch wide tile)	154.00
Double block cavity wall with 6 inches of fill-type insulation. (4 inch wide blocks)	119.00

*For normal 20 ft. high walls.

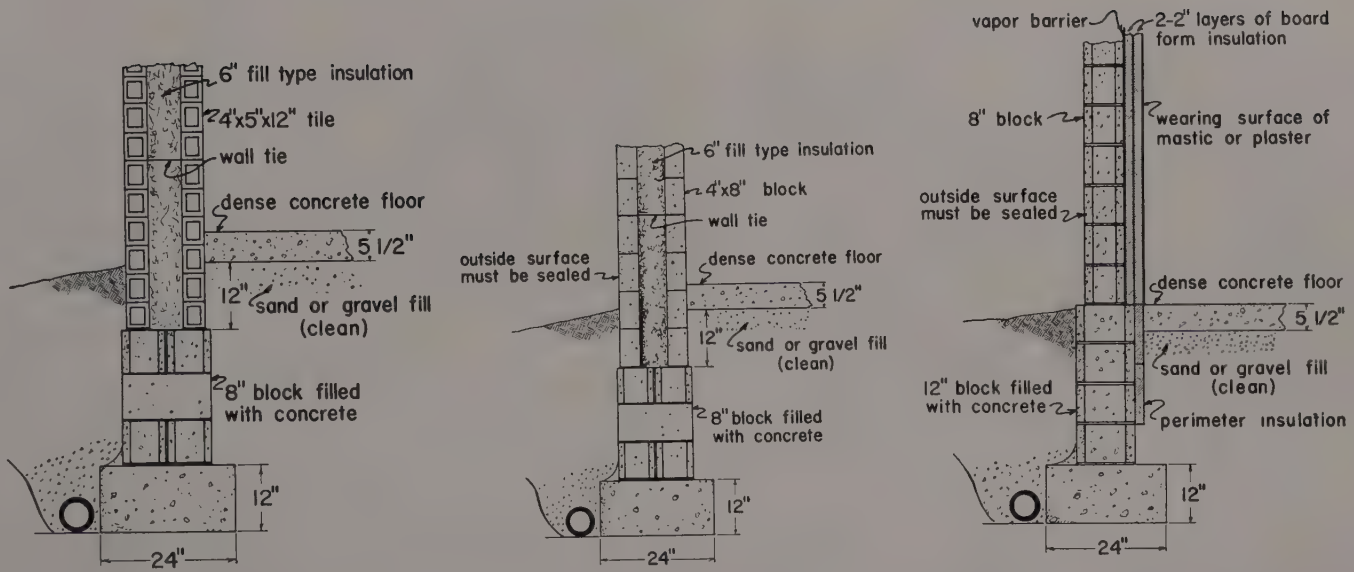

Fig. 1(A). Double tile wall with fill or granular insulation. (B) Double block wall with fill or granular insulation.

Fig. 1, (A) Double tile wall with fill or granular insula

20×20 storage has an area of 400 sq. ft., wall length of 80 ft.; a 40 × 40 storage has an area of 1600 sq. ft., a wall length of 160 ft.; a 20 × 80 storage has an area of 1600 sq. ft., but a wall length of 200 ft. Comparing the first two examples, 4 times the storage area has been obtained with only 2 times the length of wall. Comparing the second and third examples, 25 percent more wall is needed for the long, narrow room than for a square storage of equal area.

Roof Construction

The number of combinations of materials and roof designs is almost unlimited. In this project 61 combinations were evaluated for the five storage sizes studied. These were analyzed on a basis of cost per square foot for four general classes of construction: (1) Steel primary members, steel bar joists, metal deck, board form insulation, and built up roof; (2) Steel primary members, steel bar joists, board form insulation roof deck, and built up roof; (3) Steel primary members, wood joists, fill insulation, wood sheathing, and built up roof; and (4) Wood truss, wood joists, fill insulation, wood sheathing, and built up roof. The average cost for the different types of construction will be presented and discussed.

In calculating the cost of the storage structure, the assumption was made that there would be no beam or truss immediately over an outside wall if a flat roof is used; however, for a gable or arch roof it was assumed that a truss would be required over the wall. Therefore, a 40 ×60-foot structure, using a 40-foot flat steel truss on 20-foot centers would require only two trusses, whereas four wood bow-string trusses would be required. This assumption was justified on the basis that when an arch or gable roof is used, it is necessary to provide support for the roof above the side wall height and that this would cost approximately as much as a truss, if a truss were not used.

In this discussion, the term "primary support member" will be used to denote a wall, beam, or truss on which the joists rest. A tile wall supporting bar-joists (a lightweight fabricated steel supporting unit) and metal decking is illustrated in Fig. 2 and a wide flange beam supporting bar-joists and a board form insulation roof deck is shown in Fig. 3. In Table 5 are listed characteristics of primary supporting members; wide flange (W.F.) steel beams, flat steel trusses, and wood bow-string (arch trusses). The joists are the secondary

members which directly support the roof. Steel bar-joists are available in varying lengths and can be used economically up to spans of 40 feet.

Wood-joists are usually limited to a span of 24 feet. Wood-joists are in general more economical in initial cost than steel-joists, and simplify construction since they are usually spaced 16 or 24 inches O.C. where ¾-inch wood sheathing can be used as the roof base. Wood joists have the disadvantage of decaying and supporting combustion.

In planning a refrigerated fruit storage, the problem of posts or clear working area, usually arises. An analysis was made of the cost of the primary roof supporting members of 40, 60 and 80-foot wide storage buildings. (Supporting members 20-foot O.C.) The results indicated that (1) it did not cost any more to span the 40-foot storage with a single truss than to use two 20-foot beams with a post; (2) that the cost of two 30-foot steel trusses plus a post was practically the same as the cost of a 60-foot truss; (3) that the difference in cost of

Fig. 2. Tile wall supporting bar-joist and metal roof deck.

Fig. 3. Wide-flange beam supporting bar-joist and a board form insulation roof deck.

one 80-foot truss over two 40-foot trusses plus a post amounted to 11¢ per sq. foot of roof area. The dollar value or effect of having the longer trusses extend farther below the ceiling has not been evaluated and this is a point that must be given some consideration. The depth of truss is given in Table 5 and it can be observed that the longer trusses have correspondingly greater depth of section.

The roof of a storage building must be insulated with a minimum of 4 inches of board form insulation or its equivalent. If wood ceiling joists are used, the most economical method of insulating the ceiling of the building is to close the bottom of the joist with corrugated aluminum sheets or moisture resistant asbestos board nailed to the bottom of the joists. Fill or bat type insulation is placed in the space between the joints. The roof is applied over wood-sheathing nailed on top of the joists. If steel bar-joists are used to support the roof, then normally a board form of insulation is used unless a dropped ceiling is installed. The cost of board form insulation will often exceed, by as much as 30¢ per sq. ft., the cost of fill or bat-type in-

sulation. A roof using steel bar-joists, plus 4 inches of board form insulation will usually cost 50 to 70¢ more per sq. ft. than where wood joists and fill or bat-type insulation between the joists is used.

The cost of the roof, ceiling and supporting members was evaluated on the basis of type of construction and size of the storage. The five sizes evaluated were: 40 × 60, 40 × 80, 60 × 80, 60 × 120 and 80 × 120 feet. It was found that the type of construction was the factor that most influenced the cost. The results are summarized in Table 6 where the average costs (per sq. ft.) are listed for the four general types of roof construction. In general, the range of costs for a given type of construction varied plus or minus 5 percent from the average and this variation was greater than the effect of storage size. It was found that where there were several ways of arranging beams and trusses for the same size roof, there was a definite variation in cost. From an economical standpoint, it appears that the time spent in planning the roof construction is very fruitful. Important conclusions drawn regarding roof construction are: (1) There was no noticeable trend of cost per unit area in relation to size. In general, the average and the range were approximately the same regardless of the size of roof area; (2) the wide spread, plus or minus 5 percent

TABLE 5—Cost of primary support based on 20 ft. spacing and 50 lb. per sq. ft. total live load plus dead load in fruit storage construction

Type of member	Size		Span (feet)	Cost (dollars)	Cost (Dollars per sq. ft. of floor area)
	Depth of member, inch	Weight per foot of length			
WF steel beam	12″	27 lb.	20	108	0.27
	16″	45 lb.	30	270	0.45
	18″	64 lb.	40	512	0.64
	24″	84 lb.	50	840	0.84
	30″	108 lb.	60	1296	1.08
	33″	130 lb.	70	1820	1.30
	36″	150 lb.	80	2400	1.50
Steel truss, flat	36″	40 lb.	30	246	0.41
	48″	40 lb.	40	325	0.41
	72″	52 lb.	60	610	0.51
	96″	70 lb.	80	940	0.59
Wood Bowstring truss			40	250	0.31
			60	450	0.38
			80	750	0.47

TABLE 6—Roof cost as a function of type of construction in fruit storage

Construction	Average cost (dollars per square foot)
Steel primary members, steel bar-joists, metal deck, board form insulation, built-up roof	2.28
Steel primary members, steel bar-joists, board-form insulation roof deck, built-up roof	1.89
Steel primary members, wood-joist, bat, blanket or granular insulation between joists, wood sheathing, built-up roof	1.59
Wood Truss, bat, blanket or granular joists, insulation between joists, wood sheathing, built-up roof	1.42

of the average between the most expensive and most economical for a given type of construction, indicates that the roof design should be carefully planned; (3) the cost of wood joists and fill type insulation was considerably less than the cost of steel bar-joists and board form insulation, and (4) wood trusses with wood ceiling joists was the most economical type of construction.

There is a definite relationship between cost and quality in storage buildings. In Table 6, the most substantial construction, that of steel primary supports, metal bar-joists, steel roof deck and board form insulation, is the most expensive. In some cases, this construction might command a substantial reduction in insurance rates. Wood trusses are the most economical and probably will require the most maintenance.

Many storage designers believe it is not economically sound to insulate and seal around supporting members. Instead, they advocate the use of a separate ceiling below the supporting members when wood beams or trusses are used. High humidity levels that favor rot and decay are always present in a refrigerated fruit storage and it is difficult to construct and maintain a perfect vapor barrier on the warm side of the insulation. If the vapor barrier leaks, it will allow moisture to accumulate and condense in the insulation, and on the

structural timbers which will lead to rotting and roof failure. Therefore, there is justification in being reluctant to insulate around and seal in the supporting members.

A design providing ventilation of the space around wood supporting roof members will change the relative cost of the different types of roofs. Fill type insulation in a drop ceiling is more comparable cost-wise to the metal roof deck type of construction or the board form insulation roof deck type of construction than when the insulation is placed between the joists that support the roof.

Estimating the Cost of a Storage Building

The data that have been presented in Tables 2, 3, 4 and 6 can be used to estimate the cost of a storage building. The electrical and refrigeration contracts are normally separate from the building contract and they will be treated below. A cost estimate for a 40×60-foot storage building is illustrated in Table 7. The length of foundation and footing and area of floor, wall and roof can be obtained from the storage plan or sketch. The estimated cost is the sum of the unit costs as illustrated in Table 7. Any additional features of the storage must be included to have a realistic estimate. In Table 7, a single refrigerator door at $350.00 is included.

The building costs in Table 7 are calculated on the net cost basis, as mentioned above; however, if a contractor is to handle the entire

TABLE 7—Building cost estimate sheet for 40 x 60 concrete block refrigerated apple storage—12 inch filled concrete foundation wall on concrete footings, 20 ft. concrete block wall with board form insulation, steel truss roof with wood joist and fill insulation, 1—5x9 refrigeration door. (Electrical system and refrigeration system not included)

Unit of building	Unit cost	No. of units	Cost
Excavating and backfilling	$ 44.50/100 lin. ft.	2	$ 89.00
Footing	$292.50/100 lin. ft.	2	$ 585.00
Foundation (12 inch block wall filled with concrete)	$392.50/100 lin. ft.	2	$ 785.00
Floor (4 inch)	$ 27.50/100 sq. ft.	24	$ 660.00
Walls	$126.00/100 sq. ft.	40	$ 5,040.00
Roof	$ 1.59/sq. ft.	2,400	$ 3,816.00
Door	$350.00 each	1	$ 350.00
Total net cost			$11,325.00
Overhead plus profit (26½% of net cost)			3,000.00
Contractor cost estimate			$14,319.00

storage building construction, then an allowance must be made for overhead and profit which will increase the cost by about 26½ percent, which is also calculated in Table 7. In considering this cost estimate, the prices listed on Table 1 will apply. By purchasing lower cost material or higher cost material, the final price of the building can be altered considerably and these changes should be taken into consideration in preparing an estimate.

The electrical cost can be estimated as being approximately 5 percent of the net building cost.

The graph in Fig. 4 shows the estimated cost of refrigeration for average loading conditions using water cooled condensing and 3-phase electrical equipment. The data in Fig. 4 can be converted into cost for a given size storage through the use of the factor 2.5 cu. ft. of

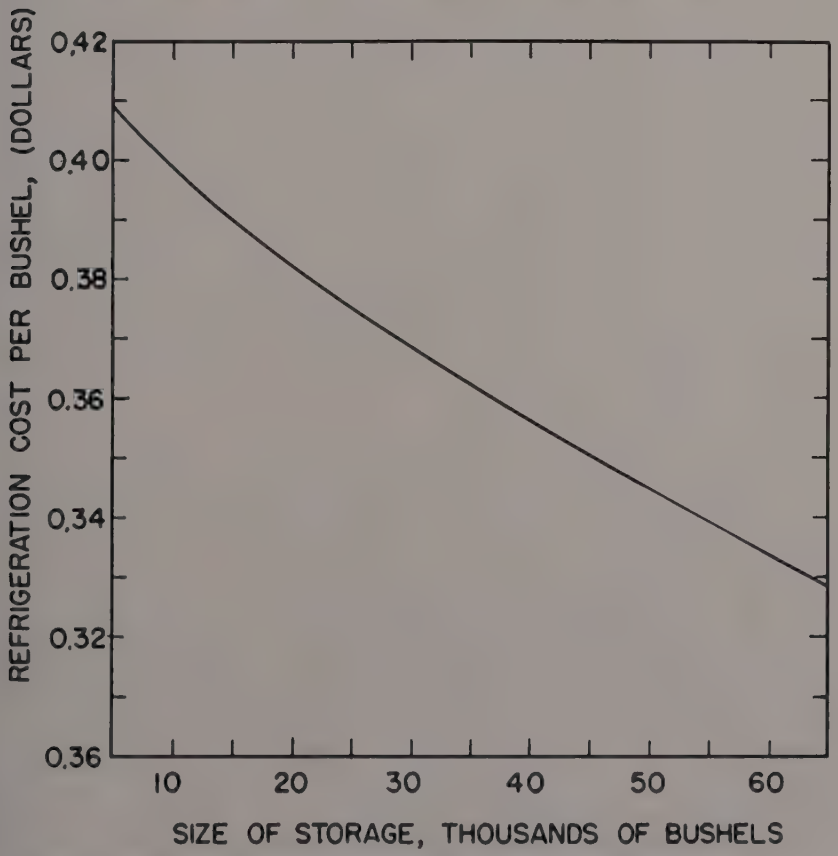

Fig. 4. Estimated refrigeration cost as a function of size of storage.

space per bushel, when the fruit is stored in crates, or 2.25 cu. ft. of space per bushel when 16 to 20 bu. bulk boxes are used. About 10 percent more fruit can be stored in the same space using bulk boxes than when crates are used.

SUMMARY

The results of a study to evaluate the cost of Michigan fruit storage building as affected by size and type of construction are presented. The relative cost of different types of foundation, floor, wall and roof construction are discussed on a unit basis so that they can be readily compared.

It was found that floor and roof cost (per sq. ft.) are not appreciably affected by size. However, wall, foundation and footing (per sq. ft.) are directly a function of the size and shape of the storage. Refrigeration costs (per bushel) decrease with increased size.

The data are presented in such a way that it is possible to use them to estimate the cost of a storage building.

The costs of different types of construction vary quite widely; however, variation in quality accompany these variations in cost. In storage building construction, quality factors are: longevity, freedom from maintenance, fire resistance, and utility. The person who is planning a storage should carefully weigh these factors in light of cost before deciding on a type of construction. In general, the resultant building will reflect its cost.

ACKNOWLEDGMENT

The authors wish to acknowledge the assistance of Dr. B. C. French who suggested this study, Mr. Larry Barker and Paul Gillett for estimates on the steel cost and to Max Udell for data on refrigeration cost.

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SCORING SCORCHED PARTICAL DISCS FOR DRY MILKS BY MEANS OF A PHOTOELECTRIC REFLECTION METER

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INTRODUCTION

Scorched particle content is one of the important factors in the grading of dry whole milk, nonfat dry milk, dry buttermilk and dry whey. Proper control requires the careful attention of the drier operator throughout the drying process. The lower the desired moisture, especially below 3.0 percent, the more care that is necessary to maintain a low scorched particle content.

U.S. Extra grade dry whole milk, nonfat dry milk and dry buttermilk standards specify that the scorched particle content shall not exceed 15mg. for the spray process and 22.5 mg. for the roller process. Furthermore, the average housewife objects to brown and black scorched milk particles in dry milks because she suspects contamination by foreign material such as dust.

The official U. S. Department of Agriculture method and the American Dry Milk Institute method require the dry sample to be reliquified with sediment free water and filtered through a standard lintine material on an area having a diameter of 1⅛ inch. The disc is gently dried in a protected area. The scorched and burned material are compared visually with the U. S. Department of Agriculture scorched particle standards for dry milks.[1]

The visual grading of borderline scorched particle contents on the discs has inherent limitations and weaknesses such as a technician's sight perception ability, carefulness and judgment. A satisfactory means of eliminating the human element would be helpful especially to standardize scorched particle ratings among techni-

[1]Strobel, D. R. and C. J. Babcock (1950). Scorched particle standards for dried milk developed. U.S.D.A. Production and Marketing Administration, Dairy Branch. 4 pp.

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cians of different laboratories. An instrumental means of measurement might improve the accuracy, especially if it would register the fine material that is not always on the surface of the disc for visual observation. Accordingly, various laboratory instruments were considered. A photoelectric reflection meter seemed to show promise on preliminary trials so it was studied more extensively.

EQUIPMENT AND PROCEDURE

The photoelectric reflection meter used in the trials was a Photovolt Model 610 consisting of controls, galvanometer and power source. The search unit composed of photocells and light was Model 610Y with a green tristimulus filter. The instrument could be used with AC power or with a 6-volt car battery.

The photoelectric meter measured the diffuse reflection from the material (scorched particle disc) and was used as an indication of the amount (for example) of scorched particles. The search unit was placed on the sample. Therefore, samples could be checked rapidly and easily.

The light hits the sample at a direction of 0 degrees and is "viewed" at an angle of approximately 45 degrees. The registration of the reflected light took place in all meridian planes, the advantage being that materials with a directional texture gave similar readings regardless of how turned within their own plane.

The instrument was adjusted so the galvanometer would indicate zero on the scale for surfaces other than black. This gave the advantage of a greater spread of reading within a specific reflectance range. This advantage is of greater importance if the difference is small for high reflectances.

The scorched particle discs were prepared mostly on spray process nonfat dry milk according to the method described in the U.S. Department of Agriculture pamphlet, "Methods of Laboratory Analysis for Dry Whole Milk, Nonfat Dry Milk Solids, Dry Buttermilk and Dry Whey," (1954).

Briefly, this consisted of reliquifying 25 grams of spray process nonfat dry milk with approximately 200 ml. of sediment free water at room temperature in a Waring Blender. Reliquified samples and rinsings were filtered through the lintine material of a No. 900 card of the Sediment Testing and Supply Company, Chicago.

The procedure for roller process nonfat dry milk consisted of

weighing a 17 gm. sample and reliquifying in a Waring Blender for 30 seconds with 200 ml. of 10 percent aqueous sodium citrate solution at 80° to 90° C. The remainder of the procedure was the same as herein given for the spray process nonfat dry milk.

Discs with 7.5, 15.0, 22.5 and 32.5 mg. of scorched and burnt dry milk material were prepared according to the method reported by Strobel and Babcock (1950). However, difficulty was encountered in obtaining duplicate results using this method. Consequently visual selection of the most representative standard discs compared to the Sepia photoprints of the U.S. Department of Agriculture scorched particle standards was made.

The galvanometer was adjusted for a reading of 100 for the blank (a clean unused disc), and at 0 with a disc having 32.5 mg. The galvanometer readings for 7.5, 15.0, and 22.5 mg. discs were obtained by mathematical calculation and checked by use of the discs with a known quantity of 7.5, 15.0, or 22.5 mg.

Scorched particle discs with galvanometer reading of 77 through 100 were scored 7.5 mg., 54 through 76 were scored 15.0 mg., 31 through 53 were scored 22.5 mg., while less than 31 to 0 were rated 32.5 mg. In visually scoring discs, any scorched particle content above 7.5 mg., but not more than 15 mg., is scored 15 mg. and above 15 mg., but not more than 22.5 mg. is scored 22.5 mg.

Operation of the Reflection Meter

The operating steps were as follows: (1) Reflection meter indicator (galvanometer) was adjusted to 0, (2) inserted green tristimulus filter into position in search unit, (3) placed switch to "on" position and turned coarse sensitivity control knob (Df) to its center position, (4) turned fine zero suppressor control knob (Bf) to its center position, (5) placed standard 32.5 mg. scorched particle disc directly on background material (four layers of lintine discs) and centered search unit opening directly over area of the disc, (6) using coarse zero suppressor knob (Bc) adjusted galvanometer to approximately 0 and made final adjustment with fine zero suppressor knob (Bf), (7) removed 32.5 mg. disc and substituted unused disc for the blank; with coarse sensitivity control knob (Dc) set galvanometer pointer on approximately 100 and corrected to 100 with fine sensitivity control knob (Df); checked 15.0 mg. and 22.5 mg. discs for the reading, and (8) proceeded to take galvanometer readings of the discs having the samples.

The customary practice was to record the average of three readings for each disc, especially if material lacked uniform distribution on the disc. After 20 samples the reading was checked on 32.5 mg. disc and on the blank disc for 0 and 100, respectively. Readjustment of the 0 setting will always require readjustment of 100 setting. The reverse is not always true.

The trials indicated that various lintine discs before use gave reasonably close reflectance readings. The readings for 36 discs ranged from 104 to 94; of these 30 were within a plus or minus 2 of 98.

EXPERIMENTAL RESULTS AND DISCUSSION

Samples of nonfat dry milk from many dairy companies were used to prepare the scorched particle discs by the official USDA method. Most of the samples represented the spray process product. Table 1 shows results of the reflection indicator readings on 20 samples with three readings on each sample within the same day. The maximum variation of galvanometer readings on the same disc was 6 and the average for the 20 samples was 3.1.

TABLE 1—Triplicate reflection meter readings of scorched particle discs

Sample number	1st	2nd readings	3rd	Difference reading	Composite score (mgs.)
1	70	68	70	2	15.0
2	77	78	77	1	7.5
3	77	77	72	5	15.0
4	78	79	78	1	7.5
5	70	70	68	2	15.0
6	77	78	74	4	15.0
7	75	75	73	2	15.0
8	84	84	85	1	7.5
9	70	67	69	3	15.0
10	75	72	74	3	15.0
11	60	60	63	3	15.0
12	70	67	68	3	15.0
13	52	52	55	3	22.5
14	77	75	72	5	15.0
15	76	76	78	2	15.0
16	84	85	89	5	7.5
17	85	87	90	5	7.5
18	85	87	91	6	7.5
19	75	77	74	3	15.0
20	57	59	59	2	15.0

The larger variation seemed to occur with the discs that had less uniform distribution of scorched particles. The search unit spot light covered an area with a diameter of ¾ inch, while the entire area exposed to the collection of scorched particles was 1⅛ inches in diameter. The disadvantage of enlarging the search unit opening to register the complete area was the possibility of causing some interference by specular reflection. Care in preparation of the discs to obtain a uniformity of scorched particle coverage will reduce the variation in galvanometer readings.

Table 2 shows the reflection readings taken the same day discs were prepared then 3 to 5 days later.

TABLE 2—Reflection meter readings of scorched particle discs held 0 days and 3 to 5 days

Sample number	Reading 0 days	Reading 3 to 5 days	Variation in readings	Composite rating (mg.)
54	85	84	1	7.5
55	88	91	3	7.5
56	69	68	1	15.0
57	82	83	1	7.5
58	74	77	3	15.0
59	70	72	2	15.0
60	64	66	2	15.0
61	79	80	1	7.5
62	79	77	2	7.5
63	62	65	3	15.0
64	79	81	2	7.5
65	14	14	0	32.5
66	32	32	0	22.5
67	59	62	3	15.0
68	56	54	2	15.0
69	48	52	4	22.5
70	36	33	3	22.5
71	52	52	0	22.5
72	32	32	0	22.5
73	62	62	0	15.0

The variation ranged from 0 to 4 with an average of 1.7 for 20 samples. These data suggest that the reflectance was not affected by holding scorched particle discs for a period up to 1 week.

The results of rating 336 scorched particle discs by the customary visual method and also by the reflectance meter method are presented in Table 3. Two hundred and thirty-eight discs (70.8 percent) were rated the same by both methods. Of the 98 samples that were

TABLE 3—Comparison of scorched particle discs evaluation by visual and meter methods

Rated visually	Rated metrically	Number of discs	Percent
IDENTICAL RATING BY EACH METHOD			
7.5	7.5	105	31.3
15.0	15.0	101	30.0
22.5	22.5	27	8.0
32.5	32.5	5	1.5
	Total	238	70.8
DIFFERENT RATING BY EACH METHOD			
7.5	15.0	2	0.6
15.0	22.5	2	0.6
22.5	32.5	6	1.8
15.0	7.5	70	20.8
22.5	15.0	18	5.4
32.5	22.5	0	0.0
	Total	98	29.2
	Total ratings	336	100.0

given different ratings by the two methods, 70 discs (20.8 percent) were rated 15.0 mg. visually but only 7.5 mg. metrically. The reverse was true of two discs (0.6 percent). Eighteen discs (5.4 percent) were assigned 22.5 mg. by the visual method and 15.0 mg. by the meter method. Only two (0.6 percent) rated 22.5 mg. by the meter and 15.0 mg. by the visual methods.

U.S. Extra grade nonfat dry milk allows both 7.5 and 15.0 mg. ratings for the spray process product. Roller process nonfat dry milk scorched particle requirement for nonfat dry milk is a 22.5 mg. rating or less. Consequently of the 98 samples, 26 (7.7 percent) would grade differently on the basis of the choice of method for rating the scorched particle discs.

CONCLUSION

The photoelectric reflection meter was used successfully to score scorched particle discs. Its use was rapid, simple and reasonably reliable. The photoelectric reflection meter method had the advantage

over the visual method of eliminating the need for technician training in scoring and it tended to reduce the variations that occurred among the scorings of several trained technicians in the same laboratory.

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SOLUBLE SALT STUDIES WITH GREENHOUSE FLORICULTURE PLANTS

A PRELIMINARY REPORT

By W. W. McCALL, R. F. STINSON and R. S. LINDSTROM

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THE MANAGEMENT OF SOILS in the greenhouse involves the use of large amounts of fertilizer. The application of fertilizer materials to greenhouse soils often exceeds 3,000 pounds per acre. This leads to the accumulation of soluble salts in these soils. When a grower notices that his plants are not growing very well, the tendency is to add more fertilizer in order to promote better growth. This may aggravate the problem of soluble salts and cause heavy damage to the crop being grown.

The problem of soluble salts in greenhouses is more prevalent than is generally realized. Merkle and Dunkle (3) reported that approximately 20 percent of 300 greenhouse samples tested had accumulated excessive amounts of soluble salts. Kelly (4) reported that soluble salts are a frequent trouble in New York greenhouses and Page (6) indicated that greenhouse soils in Ohio are often over fertilized, resulting in soluble salt problems. A survey of 73 greenhouse soils tested over a period of 1 year by the Michigan State University Soil Testing Service at East Lansing, indicated that 65 percent of these samples contained excessive amounts[1] of soluble salts and an additional 8 percent contained levels that were dangerous[2] due to the possibility of high soluble salts from the addition of more fertilizer to these soils.

This work was conducted to determine at what levels various floricultural plants would be affected by soluble salt levels in greenhouse soil.

[1]In excess of 100 x 10^{-5} mhos.
[2]80-100 mhos x 10^{-5}

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PROCEDURE

These experiments were conducted during the winter of 1957 in the Michigan State University greenhouses. A steam sterilized greenhouse soil mixture composed of two parts loam soil (surface 6 inches of Conover loam), 1 part sand and 1 part peat, with pH 6.0 was used. A 15-10-5 liquid fertilizer was added at 2,000, 4,000, 6,000, 8,000 and 10,000 pounds per acre (4, 8, 12, 16, 20 pounds per 100 sq. ft., respectively). Check treatments were also used.

Soluble salt determinations were made by the method of Merkle and Dunkle (1) which measures the electrical conductivity of a 1:2 soil-water extract. A Solu-Bridge soil tester, Model RD-15,[3] was used to determine the conductivity of the soil. All measurements are as mhos $\times 10^{-5}$.

Seventeen floricultural plants (shown in Table 1) often grown in the greenhouse were treated as above. The fertilizer was added directly to the surface of the soil and watered in thoroughly with distilled water. Soil samples were taken as soon as evidences of soluble salt injury were shown by plant appearance. Where the plants were still living at the end of 2 weeks a second application at the above rates was made.

The plants were harvested at the time that soil samples were taken and dry weights were determined.

RESULTS AND DISCUSSION

Fig. 1 shows the effect of the added fertilizer upon the soluble salt levels in the soil. The soluble salt level of the soil increased rapidly with the addition of fertilizer up to 12,000 pounds per acre. With the addition of 14,000 and 16,000 pounds per acre little increase occurred but there was a sharp increase in soluble salt level when 18,000 and 20,000 pounds per acre was added to the soil. This would indicate that the soil had sufficient buffer capacity to contain the soluble salt levels below 16,000 pounds per acre; however, when greater amounts of fertilizer are added the soluble salt levels increased rapidly.

Table 1 presents the effects of soluble salt levels upon the growth of plants. These data are presented according to the soluble salt level at which the growth and yield of plants is reduced but no visual symptoms appear on the foliage of the plant, the level at which visual symptoms can be seen and the level at which death occurred for each

[3]Manufactured by Industrial Instruments, Cedar Grove, N. J.

plant. It will be noted that death did not occur for two of the plants, Amaryllis, and Sansevieria, and no visible symptoms occurred for either of these plants although salt toxicity symptoms did occur on Oxalis, a weed, which was growing in the pots with the Amaryllis.

These values are of importance as an indication that many plants may be reduced in yield or quality because of soluble salts without visual evidence that the problem exists. The only way of detecting this problem is by periodic soil tests which provide a means of preventing the application of too much fertilizer to the soil. These data

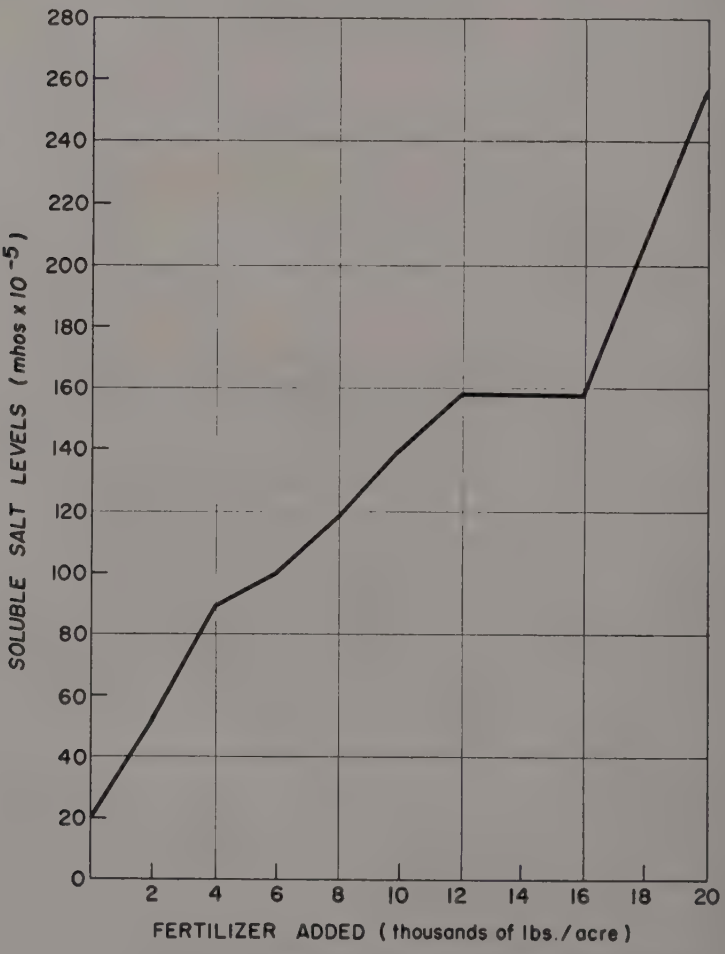

Fig. 1. The effect of rate of application of fertilizer (15-10-5) on the soluble salt level in a greenhouse soil.

TABLE 1—The effect of soluble salt levels upon the growth of several greenhouse plants

Plant	Appearance of the plant		
	Reduced growth but no visible symptoms	Reduced growth with visible symptoms	Plant dead
	mhos x 10^{-5} (*a*)	mhos x 10^{-5}	mhos x 10^{-5}
African violet	55	80	100
Amaryllis	160	—	—
Begonia	90	140	260
Calceolaria	60	88	140
Chinese evergreen	55	160	210
Cineraria	55	90	140
Chrysanthemum	55	90	140
Coleus	55	80	140
Geranium	55	90	175
Peperomia	90	140	260
Petunia	—	50	100
Philodendron cordatum	90	140	220
Pilea	55	85	100
Poinsettia	89	106	150
Primula	90	140	180
Roses	82	100	150
Sansevieria	180	—	—

(*a*) Determined by conductivity of 1:2 soil-water extract.

show also that once the visual symptoms appear on the plant, the damage of reduced yield has already occurred. This would indicate that growers who depend upon visual symptoms as a means of diagnosing their problems are making a mistake in their management systems. It further indicates the value of soil testing cannot be minimized in the greenhouse management program as a means of preventing the loss of yield and quality from excess fertilization.

In Table 2 the plants are presented according to the degree of their sensitivity to soluble salt levels in the soil. This classification is based upon the appearance of visual symptoms upon the plant. The discussion above would indicate that this system of classification should be modified to show their sensitivity to reduced yields with no visual symptoms apparent. However, the system presented agrees with the other for all plants grown except the Chinese Evergreen. This plant would be classified as most sensitive as reduced yield occurred at 55 mhos $\times 10^{-5}$, but visual symptoms did not appear until the salt levels were at 160 mhos $\times 10^{-5}$ which places this plant in the tolerant range. Amaryllis and Sansevieria first showed reduced growth

TABLE 2—Arrangement of plants on basis of sensitivity to soluble salt levels in the soil as indicated by the appearance of visual symptoms on the plant leaf.

Sensitive plants 80-100 mhos x 10^{-5} (*a*)	Moderately sensitive 100-140 mhos x 10^{-5}	Tolerant 140+mhos x 10^{-5}
African violet	Begonia	Amaryllis
Calceolaria	Peperomia	Chinese evergreen
Chrysanthemum	Philodendron cordatum	Sansevieria
Cineraria	Poinsettia	
Coleus	Primula	
Geranium	Rose	
Petunia		
Pilea		

(*a*) Determined on 1:2 soil-water extract.

at 160 mhos $\times$ 10^{-5} but no visual symptoms or death resulted with soluble salt levels as high as 260 mhos $\times$ 10^{-5} which were attained in this experiment.

Visual symptoms upon the plant usually occurred within 7 to 10 days after the application of excessive amounts of fertilizer to the soil although it may occur as soon as 24 hours and as late as several weeks, after repeated application of fertilizer to the soil.

The data in Table 3 show the effect of increasing amounts of fertilizer upon the growth of eight of the greenhouse plants. These plants represent all degrees of sensitivity of plants grown. These data show that 2,000 pounds per acre of this fertilizer increased yields

TABLE 3—The effect of increasing fertilizer application upon the dry weight of several greenhouse plants.

Plant	Treatment(*a*)								
	None	2000	4000	6000	8000	10,000	12,000	16,000	20,000
	gms.	gms.	gms.	gms.	gms.	gm.s	gms.	gms.	gms.
African violet	49.8	49.5	44.9	32.5	25.7	2.5	—	—	—
Amaryllis	59.1	—	81.1	—	68.6	—	67.0	48.6	37.8
Begonia	229.7	226.0	208.0	145.6	131.6	77.0	—	—	—
Chrysantehmum	21.1	43.2	34.4	13.3	12.8	4.7	—	—	—
Cineraria	126.0	105.0	77.0	112.0	84.0	48.0	—	—	—
Philodendron cordatum	10.6	—	9.5	—	7.4	—	6.2	7.7	2.4
Pilea	19.9	15.2	13.3	14.1	8.5	7.4	—	—	—
Sansevieria	68.7	—	91.1	—	43.9	—	28.4	28.1	28.2

(*a*) Pounds per acre of 15-10-5 liquid fertilizer.

over no fertilizer except in the case of the most sensitive plants as represented by Pilea (aluminum plant). Four thousand pounds per acre of this fertilizer decreased the yields of all plants except those most tolerant to soluble salts as represented by Amaryllis and Sansevieria. Eight thousand pounds reduced the yield of all plants irrespective of their tolerance to soluble salts. In most instances, plants receiving this level of fertilization were severely damaged or dead except those with the greatest degree of tolerance to soluble salts.

SUMMARY AND CONCLUSIONS

Soluble salt studies were conducted with 17 common greenhouse plants grown on a mixed greenhouse soil commonly used in the greenhouses at Michigan State University. A 15-10-5 liquid fertilizer was added at 2,000, 4,000, 6,000, 8,000, and 10,000 pounds per acre. Second applications were made at the end of 2 weeks where plants were still living.

Soluble salt levels were determined when symptoms appeared upon the leaves of the plants. This usually occurred within 1 week to 10 days after application although it may occur as soon as 24 hours after application and as late as several weeks, after repeated application of fertilizer to the soil.

The plants tested were classified according to their sensitivity to soluble salt levels in the soil based upon the appearance of visual symptoms on the leaf of the plant.

On the basis of the data obtained in this experiment the following interpretation of soluble salt tests in greenhouse soils of Michigan may be utilized for floricultural crops.

0-30 soils may be deficient for plant growth.

30-50 satisfactory range for plant growth.

50-90 plants are reduced in growth but seldom show visual symptoms.

90-140 plants are stunted or wilted, edges of leaves are burned and sensitive plants may be killed.

140-300 most plants will be killed.

300 plus most tolerant plants may be killed or stunted.

Additional research is needed to determine the effect of different fertilizer salts upon the sensitivity of plants, the effect of different

methods of application of fertilizers upon the soluble salt status of soils and to determine the response of other common greenhouse plants to the soluble salt levels in the soil.

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EXPERIMENTS IN HARVESTING CHERRIES MECHANICALLY[1]

A PROGRESS REPORT

By H. P. GASTON,[2] J. H. LEVIN[3] and SCOTT HEDDEN[3]

MICHIGAN CHERRY GROWERS pay more than $4,000,000 annually to the workers who harvest their fruit. The hand picking methods now used require large numbers of people, many of whom come from other states and/or foreign countries. These workers are difficult to recruit and hard to manage. They are usually paid piece-work rates, and in their efforts to earn maximum wages they often do considerable damage to the fruit they pick. Cherry growers need a less expensive and more satisfactory method of harvesting the crop. Industry leaders feel that the only way to achieve this end is by mechanization. Mechanical picking has proved successful in California for the harvest of nuts and prunes.

During the 1956 season Michigan State University and the U.S. Department of Agriculture initiated cooperative studies to: (1) develop practical mechanical cherry harvesting equipment, (2) provide effective means of collecting and transferring fruit mechanically harvested and (3) remove leaves, stems and other foreign material from mechanically harvested fruit. The ultimate purpose of the work was to simplify management, reduce harvesting costs and increase net returns to growers. Trials are still in progress and results therefore are not conclusive and should not be considered as recommendations. Due to the wide-spread interest in the subject, however, a report of progress is presented.

[1]Based on work carried out jointly by the Fruit and Vegetable Harvesting Section, Harvesting and Farm Processing Branch, Agricultural Engineering Research Division and departments of horticulture and agricultural engineering, Michigan State University, East Lansing.

[2]Department of Horticulture, Michigan State University.

[3]Agricultural engineers, Agricultural Engineering Research Division, A.R.S., U.S.D.A.

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METHODS

Harvesting

In 1956 a variety of hand and pole shaking methods were tried. These included the hand-shaking of limbs of various sizes, the use of hand-held pole shakers with various types of hooks at the end and short lengths of rubber hose used to strike the branches. Although cherries were separated from the tree by these methods, the work was exhausting.

During the 1957 season several types of mechanical shakers activated by compressed air were tried but none proved satisfactory.

Early in 1958 a tractor-mounted, hydraulically-activated boom-shaker capable of moving the primary branches of a bearing tree through an amplitude of 1.5 inches, at the rate of 500 to 800 cycles per minute, was made available for experimental use (see Fig. 1). This piece of equipment — the most effective yet tried — enabled the operators to separate in seconds amounts of fruit that had formerly required minutes. The results reported here were achieved by using this machine and the fruit collecting unit built in 1958.

The shaker was attached to the tree by means of a hydraulically-activated mechanical "claw." This device tended to damage the tree at the point of attachment. It was found, however, that practically all such injury could be prevented by wrapping the tree trunk or branch with a piece of rubber belting.

Fruit Collecting.

During the 1956 season the mechanically harvested cherries were collected on a tarpaulin laid on the ground under the tree. The fruit was moved to a central point from which it could be transferred to lugs by lifting the corners of the tarpaulin.

In 1957 a rectangular cloth-covered metal collecting-frame was constructed and tried. This 12 x 24-foot device, mounted on wheels, funneled the fruit to a central point, but the size and shape of the unit made it hard to move from tree to tree. There was also a tendency for the cherries to "pocket."

During the 1958 season the fruit collecting unit shown in Fig. 1 was developed, constructed and tested. This unit had a radius of 11 feet when opened. It was mounted on wheels and could be folded. These features made it relatively easy to move the device from tree

Fig. 1. Tractor-mounted hydraulic shaker developed by Gould Bros. and the semi-circular fruit collecting unit used in the trials. The cherries were transferred to lugs by means of the hand-cranked conveyor shown at left center.

to tree. It had a flexible section which fitted against the tree trunk; and the hand-cranked conveyor, which was a part of the device, provided an effective means of transferring the fruit to lugs.

Cleaning Fruit

Mechanical shakers bring down leaves, twigs and other foreign material which collects with the fruit. The removal of this material is a necessary part of mechanical harvesting. The cleaning equipment used during the 1958 trials varied from a simple and inexpensive sorting table to a commercially-made fanning mill which cost several hundreds of dollars.

Chemical Aids to Fruit Drop

Although untreated cherries can be separated from the tree by shaking, a chemical which would loosen them would make separation easier and more complete. The effects of eight chemicals, which it

was hoped would serve this purpose, were studied. These materials were applied as a spray to both sweet and tart cherries. This phase of the work was directed by Dr. Charles Hamner, department of horticulture, Michigan State University.

RESULTS

Results obtained with the hydraulic shaker described above are summarized in Tables 1 and 2.

Sweet Cherries — Windsors

Most of the Windsor cherries grown in Michigan are made into maraschinoes. Inasmuch as the fruit that goes to this market must be picked before it has developed deep red color, the cherries are harvested before they reach "fresh market" maturity. At this stage they are still firmly attached and are hard to separate by shaking. Shaking approximately seven days before fresh market maturity separated less than 75 percent of the fruit. From 36 to 53 percent of the cherries came off the tree with stems attached. From 38 to 42 percent of the fruit that came off was bruised during the shaking operation. The results led to the conclusion that unless an effective chemical aid could be developed, this equipment could not be used to advantage in harvesting this variety of cherry at the stage of maturity desired by the maraschino packer.

The work with this variety also showed that the cherries which are going to fall come off during the first few seconds. Prolonged shaking tended to bruise the fruit without materially increasing the quantity separated.

TABLE 1—Results obtained when a hydraulic boom-shaker, semi-circular catching device and an on-the-ground canvas were used by a four-man-team in harvesting Windsor and Schmidt cherries

Variety and tree number	Number of "sets"	Shaking time	Cherries on tree	Cherries separated by shaking	Separated cherries with stems	Separated cherries bruised	Days before maturity	Damage to bark
		seconds	*pounds*	*per cent*	*per cent*	*per cent*	*days*	
Windsor 1	4	60,45,30,15	143	68	53	42	7	considerable
Windsor 2	3	10, 10, 10	119	74	36	38	7	moderate
Windsor 3	2	10, 5	128	83	19	19	0	slight
Schmidt 1	2	15, 15	123	78	22	22	0	moderate
Schmidt 2	3	10, 10, 5	116	88	19	16	0	slight
Schmidt 3	2	10, 10	132	83	23	9	0	slight

TABLE 2—Results obtained when a hydraulic boom-shaker, a semi-circular catching device and an on-the-ground canvas were used by a four-man-team in harvesting Montmorency cherries

Tree number	Number of "sets"	shaking time	Cherries on tree	Cherries separated by shaking	Separated cherries with stems	Separated cherries bruised	Days before maturity	Damage to bark
		seconds	*pounds*	*per cent*	*per cent*	*per cent*	*days*	
1	3	5, 5, 5	88	81	8	2	0	none
2	2	10, 10	96	90	8	4	0	slight
3	2	5, 5	112	78	9	3	0	none
4	2	5, 5	93	86	7	2	0	none
5	3	5, 5, 5	91	92	6	1	0	none
6	2	5,5	84	88	5	3	0	slight
7	3	5, 5, 5	90	84	7	3	0	none
8	2	10, 10	114	91	6	2	0	none
9	2	5, 5	87	85	9	4	0	slight
Average	2.3	13.0	95	86	7.8	3		

The shaker was used in harvesting one Windsor tree which was allowed to bring its fruit to fresh market maturity. A greater percentage of the cherries (83 percent) came off, and a lesser amount (19 percent) showed evidence of mechanical injury. The amount of damage was, however, considered excessive.

Sweet Cherries — Schmidt

Shaking periods of 20 to 30 seconds separated from 78 to 88 per cent of the fruit. From 19 to 23 per cent of the cherries fell with stems attached, and from 9 to 22 percent of them were bruised during the operation.

Tart (Montmorency) Cherries

The results of the work with tart cherries are summarized in Table 2. The data show that, on the average, a total shaking time of 13 seconds brought down 86 percent of the fruit. Approximately 8 percent of the cherries came off with stems attached, and 3 percent of the fruit was bruised during the harvest operation. Although even a small amount of bruising is objectionable, it should be pointed out that hand-picking also causes this type of injury. A federal-state inspector who scored several lugs of mechanically harvested cherries for bruises found that they compared favorably with conventionally picked fruit, graded the same day. Subsequent observations by the authors confirmed this finding.

Fruit Cleaning Units

One of the commercially made air-blast cleaning units tested during the 1958 season successfully removed the foreign material collected with machine-harvested cherries. While this particular unit was not of large capacity, the results indicated that the principle was sound. If a demand develops for large-capacity cleaners of this type, manufacturers who deal in such equipment will no doubt make them available.

Chemical Aids

Two of the eight chemical "looseners" tested made it somewhat easier to separate the cherries from the stems, and the stems from the spurs on which they grew. It will be necessary to do more work on this phase of the study before definite conclusions can be reached.

DISCUSSION

Several minutes were required to transfer the harvested cherries from the collecting unit into lugs and to move the equipment from tree to tree. However, time studies showed that under favorable conditions it would be possible for a four-man-team to harvest from 1,200 to 1,500 pounds of cherries per hour. If the men were paid $1.50 per hour, the labor cost of harvesting the fruit would be approximately ½ cent per pound.

The equipment used in the trials cost approximately $2,000. If depreciated over a four-year period, the machines would cost a grower who used them in harvesting 50 tons of cherries about ½ cent per pound. The total cost of one cent per pound compares favorably to the 2½ cents which growers often pay for hand picking.

However, several other factors need to be considered including value of fruit left on tree, removal of foreign matter, terrain and orchard cover and shape and size of tree.

Much of the fruit left on the tree lacked size, color and maturity and thus was inferior to that which came off more readily. One way to save this fruit is to pay workers a premium sufficient to induce them to pick it by hand. A second method would be to shake the trees again after the cherries have become mature. The following example indicates that the savings with mechanical harvesting may more than offset the loss in production if this fruit is left unharvested. Assume that:

The grower involved produces 60 tons of cherries
Processors are paying 8 cents a pound
Mechanical harvesting leaves 10 percent (6 tons) unharvested
Labor cost of hand-picking is 2½ cents a pound
Labor cost of machine-picking is 1 cent a pound
Other costs are equal

Under these conditions the value of the fruit left on the tree would be $960. However, costs of mechanical harvesting would be $1,920 less than costs of hand-picking. This means that the grower would realize $960 more by harvesting 90 percent of his crop mechanically than he would by picking all of it by hand.

Foreign material can be removed by running the fruit through an air-blast cleaner or by floating it out at the time the cherries are put into water. The operation would, of course, cost money; but it is believed that this, and the other additional expenses incident to mechanical picking, would be offset by the economies which could be expected. For example, the grower who mechanizes his harvest operation will not need as many workers. He will therefore be spared the expense of recruiting, housing and supervising the additional workers needed when cherries are hand picked.

The clearance between the ground and the under-carriage of the fruit collecting unit used in 1958 was 4 inches. This feature made it difficult to maneuver the unit in sod orchards in which the cover was thick and tall. Irregularities in the terrain added to the difficulty of moving the collecting unit quickly and easily from tree to tree. Most of these difficulties could be eliminated by mowing the sod before harvest and/or by redesigning the fruit collecting device.

A boom-shaker is most effective when it can be attached to the trunk of a relatively small, high-headed tree or to the scaffold branches of a large tree. This means that a shaking unit cannot be used effectively on small low-headed trees or on large ones that have more than 3 or 4 scaffold branches. Fruit that is borne on long slender "hanging" branches is also difficult to harvest with a shaker. For best results it will probably be necessary to train trees to types which lend themselves to mechanical harvesting. Some structural difficulties could probably be overcome by corrective pruning. Variety affects tree size, structure and the difficulty of fruit separation. These and other factors, such as the possible root damage caused by shaking, are being investigated.

EFFECTS OF NITROGEN, PHOSPHORUS, POTASSIUM AND MAGNESIUM FERTILIZERS ON YIELD AND PETIOLE NUTRIENT CONTENT OF A CONCORD GRAPE VINEYARD

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RECENT CHANGES in fertilizer usage and increased evidence of nutrient deficiencies led to the establishment of this investigation.

Early experiments in the United States (6, 14) showed the benefit of commercial nitrogen for grape vineyards. As a result of these and other experiments (14,16), fertilizer usage in Michigan vineyards tended toward only nitrogen and/or farm manure.

Lagatu and Maumé (10) stressed the need for a balanced supply of nitrogen, phosphorus, and potassium in the vineyards of France. Gladwin (7) reported the need for nitrogen and potassium, with phosphorus being of doubtful value in New York vineyards.

This questionable effect of phosphate fertilizers on either vine growth or yield has been reported also by Partridge and Veatch (16) Shaulis (19) and Ulrich (23). Conversely, Randolph (18) obtained in Texas more vigorous growth and higher yields with the grape variety Carman wherever phosphorus was used than was obtained with treatments of nitrogen alone, nitrogen and potassium combined, or no fertilizer.

Deficiencies of potassium on grapes have been reported from many parts of the world including France (10), Germany (26), New Zealand (1), and the United States (2, 5, 22). Potassium deficiencies have resulted in yield reductions in all these areas. Applications of potash

[1]The authors gratefully acknowledge the cooperation of John P. Tomkins, N.Y. Agr. Expt. Sta., Geneva, formerly, Dept. of Horticulture, Mich. State Univ., E. Lansing, in the initial establishment of this study.

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in amounts up to 540 pounds of K_2O per acre (12) have been necessary to correct this deficiency.

The use of potassium sulfate in preference to potassium chloride on grapes has been suggested by some workers (3, 19, 25). It was the opinion of Vinet that the chloride ion hindered the action of the K_2O while the sulfate ion favored this action.

Parups (17) working with Montmorency cherry trees grown in sand culture found that increasing the levels of chlorides in the nutrient solution depressed growth and the absorption of potassium by over 50 percent, as shown by leaf analysis. Increasing the sulfate content of the nutrient solution had no significant effect on potassium absorption.

Dilley (4) reported similar results with cherries, apples and peaches.

Potassium deficiency of vineyards in Michigan has been reported (13) since the initiation of this investigation.

Magnesium deficiency has been of limited occurrence in most grape areas in the northern United States. Due to its widespread occurrence in tree fruits (9), magnesium fertilizer has been included in this investigation.

Thus, the purpose of this study was to determine the individual effects of nitrogen, phosphorus, potassium and magnesium on growth, production, and petiole nutrient composition of a bearing Concord vineyard; and also to compare different sources of potash. The study was conducted for 5 years, 1953-1957.

EXPERIMENTAL PROCEDURE

Six fertilizer treatments having four replicates were established in a commercial vineyard located in the Lawton area of southwestern Michigan in the spring of 1953. The experiment was designed to allow comparisons between 40 and 80 pounds of nitrogen, zero and 60 pounds of P_2O_5, zero and 120 pounds of K_2O from either sulfate or chloride sources, and zero and 60 pounds of MgO per acre, as shown in Table 1.

Each plot consisted of six vines with four randomized replications. Treated plots were in single rows separated by border rows. All treated vines were balanced pruned to the 30 + 10 method.[2]

The treated vineyard was a high-producing vineyard growing on

[2]Thirty buds were left on each vine for the first pound of year-old prunings removed. An additional 10 buds were left for each additional pound removed.

TABLE 1—Treatments and fertilizer materials used to make up each treatment

Treatment number	Treatment pounds/acre				Individual materials required/acre				
	N	P_2O_5	K_2O	Mgo	Ammonium nitrate 33%	Superphosphate 20%	KCl 60%	K_2SO_4 48%	Sul-Po-Mag 21.5% K_2O 18.5% MgO
1	40	80	120	60	121	400		104	325
2	80	80	120	60	242	400		104	325
3	80	80	120	0	242	400		250	
4	80	80	120	0	242	400	200		
5	80	80	0	60	242	400			$MgSO_4$-368#
6	80	0	120	60	242			250	

a good sandy loam soil. It was located on an excellent grape site and considered to be one of the better vineyards in the area.

During late July of 1954 through 1957, petiole samples were taken from the four center vines of each plot. From each vine, about 20 petioles were selected from recently matured leaves just beyond the fruit clusters on each cane. Petiole samples were analyzed for nine nutrient-elements. Nitrogen was determined by the Kjeldahl method. Potassium determinations were made with a flame photometer. Spectrographic determinations were made for phosphorus, calcium, magnesium, manganese, iron, boron and copper.

During the harvest season, all of the grapes from each plot were picked and weighed. Yield data were calculated as average weight per vine.

During late July, 1956, soil samples for each plot were taken from the surface 6 to 8 inches, about 1 foot away from each vine. These were analyzed for exchangeable calcium, magnesium, and potassium according to a method previously used (13). The samples were also tested for pH, reserve and active phosphorus and potassium (21).

No data were collected during 1953.

RESULTS AND DISCUSSION

Table 2 shows a summary of yields and petiole composition for the six fertilizer treatments. The figures are shown as combined averages for the 4 years 1954-1957. There were no significant effects on yield or soil tests with any fertilizer treatment nor on petiole composition between any differential treatments of nitrogen, phosphorus

or magnesium. The only apparent significant differences were in treatment 5 in which no potassium was applied. In this case, petiole potassium was significantly lower than all other treatments.

In view of the excellent condition of the experimental vineyard, the apparent lack of treatment response, particularly on yield, was not unexpected. At no time were individual treatment yields below 19.7 pounds per vine. Vine growth during the entire period of the experiment was excellent in all plots. However, during the last 2 years of the experiment, slight potassium deficiency symptoms appeared in one replication of the no potash treatment.

TABLE 2—Grape fertilizer trials—Larry Stainton vineyard, Lawton, Michigan average 1954-1957

	Treatment—lbs./acre						
	40-80-120(a)	80-80-120(a)	80-80-120	80-80-120	80-80-0(a)	80-0-120(a)	
Yield—lbs./vine	24.4	23.1	23.8	25.1	22.9	24.7	N.S.
Petiole N —% dry wt.	.84	.89	.92	.88	.87	.88	N.S.
Petiole P —% dry wt.	.20	.21	.17	.16	.20	.16	N.S.
Petiole K —% dry wt.	2.29	2.20	2.22	2.25	1.27	2.19	[1] **
Petiole Mg—% dry wt.	.46	.53	.46	.48	.70	.49	[2] **
Petiole Ca —% dry wt.	1.37	1.38	1.47	1.57	1.36	1.37	N.S.
Petiole Mn—ppm dry wt.	211	201	218	224	240	223	N.S.
Petiole Fe —ppm dry wt.	61	62	59	57	63	54	N.S.
Petiole B —ppm dry wt.	19	21	18	19	20	19	N.S.
Petiole Cu —ppm dry wt.	25	20	22	25	23	27	N.S.

[1] L.S.D.—.01 = .56 [2] L.S.D.—.01 = .16.

	(Soil Tests—1956 only)						
pH	6.5	6.6	6.5	6.7	6.6	6.5	
P—#/Acre Reserve	136	126	136	148	151	121	N.S.
P—#/Acre Active	16	18	16	18	19	12	N.S.
K—#/Acre Reserve	89	87	79	60	50	114	N.S.
K—#/Acre Active.	91	86	80	98	64	82	N.S.
K—Exch.—me/100 g.	.20	.11	.11	.06	.06	.12	N.S.
Mg—Exch.—me/100 g.	.34	.62	.83	.66	.89	.77	N.S.

(a) Plus 60 lbs. MgO per acre.

These results give general support to results obtained by several other workers including Holland (8), Partridge (14, 15), and Van Haarlam (24) in that the normal bearing vineyard has a rather wide adaptability to different nutrient levels. There are, however, certain relationships which warrant more discussion.

Yearly comparisons of yield and nutrient composition for various paired treatments are shown in Table 3.

The comparison of applying 40 with 80 pounds of actual nitrogen per acre showed no significant difference in either yield or nitrogen

TABLE 3—Yearly averages of yield and nutrient element content of paired treatments

Treatment number		Yield (pounds/vine)					Nutrient element content (% dry weight)				
		1954	1955	1956	1957	Av.	1954	1955	1956	1957	Av.
		A. 40 vs. 80 pounds actual nitrogen									
1	40	23.0	25.0	28.2	21.5	24.4	0.81	0.81	0.71	1.02	0.84
2	80	22.0	25.2	25.2	19.7	23.1	0.88	0.81	0.79	1.09	0.89
		B. No phosphorus vs. 80 pounds P_2O_5									
6	0	23.5	25.2	26.2	24.0	24.7	0.10	0.20	0.15	0.16	0.16
2	80	22.0	25.2	25.2	19.7	23.1	0.24	0.23	0.18	0.17	0.21
		C. Potassium sulfate vs. potassium chloride									
3	K_2SO_4	24.2	25.5	25.5	20.0	23.8	2.26	2.38	1.78	2.46	2.22
4	KCl	23.2	25.5	29.7	21.7	25.0	2.31	2.24	1.71	2.75	2.25
		D. No potassium vs. 120 pounds K_2O (as K_2SO_4)									
5	0	23.5	24.5	22.5	21.2	22.9	1.50	1.25	1.12	1.19	1.27** L.S.D. .01 = .56
2	120	22.0	25.2	25.2	19.7	23.1	2.28	2.29	1.82	2.40	2.20
		E. No magnesium vs. 60 pounds MgO									
3	0	24.2	25.5	25.5	20.0	23.8	0.51	0.51	0.37	0.46	0.46** L.S.D. .01 = .16
2	60	22.0	25.2	25.2	19.7	23.1	0.70	0.56	0.42	0.45	0.53

content of the petioles. There was no influence on yield when 80 pounds of P_2O_5 per acre were applied. However, petiole phosphorus was increased slightly but not significantly. No significant differences were found between the use of potassium chloride and potassium sulfate. When potassium was omitted from the fertilizer there was a significant reduction in petiole potassium but no reduction in yield. Using 60 pounds of MgO per acre did not increase either petiole magnesium or yield.

These results further confirm previous observations that normal or healthy vineyards will not respond to applications of fertilizer other than nitrogen. The data, also, suggest that the rate of nitrogen application may be reduced considerably without influencing yield. Apparently a reduction in the potassium level within the plant does not have any serious influence until it reaches the initial level of near deficiency. The rate of decrease in petiole potassium observed in this study suggests that normal vineyards showing a petiole potassium value of 2.00 percent may not respond to additional potash applications for 5 or more years.

The interrelationship between potassium and magnesium was very evident as judged by correlation coefficients. In every year, there was a significant negative correlation between these elements as fol-

lows: 1954,—.469*; 1955,—.878**; 1956,—.879**; 1957,—.823**. This again illustrates the pronounced effect that potassium has on magnesium. Thus, excessive use of potash fertilizer may result in a magnesium deficiency earlier than would occur through normal depletion of available magnesium.

SUMMARY

The effects of nitrogen, phosphorus, potassium and magnesium fertilizers on yield, petiole analysis, and soil analysis of a bearing Concord vineyard were studied over a period of 5 years. Treatments were designed to study 40 versus 80 pounds actual nitrogen per acre, no phosphorus versus 80 pounds P_2O_5 per acre, no potassium versus 120 pounds K_2O per acre, no magnesium versus 60 pounds MgO per acre, and potassium sulfate versus potassium chloride.

There were no significant differences between yield or soil test results with any fertilizer treatment nor on petiole composition between any differential treatments of nitrogen, phosphorus or magnesium.

There was a highly significant reduction of petiole potassium in the no potash treatment and this was accompanied by a significant increase in petiole magnesium in the same treatment. This interactive effect between potassium and magnesium was further evidenced by a significant negative correlation.

The results further suggest that (1) high yields of Concord grapes in Michigan can be maintained with lower rates of nitrogen than are now being applied by many growers, (2) phosphorus and magnesium need not be included as a part of the normal grape fertilizer program, (3) sustained yields can be maintained in productive, fertile vineyards without annual applications of potassium, (4) potassium sulfate and potassium chloride are of equal value as a source of potash fertilizer, and (5) magnesium deficiency can be induced by excessive applications of potassium.

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THE STORAGE QUALITY OF JONATHAN APPLES IN RELATION TO THE NUTRIENT LEVELS OF THE LEAVES AND FRUITS

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THE USEFULNESS of leaf analysis has been demonstrated by numerous surveys of the nutrient status of the trees in relation to vegetative growth and fruit yields. At present leaf analyses may serve as a practical basis for fertilizer applications. However, the relationship of keeping quality and development of storage disorders of the fruit to the nutrient level of the foliage and fruits has not been as well studied.

This study was planned to ascertain the mineral content of the leaves and fruits as related to fruit quality during regular refrigerated and controlled atmosphere storage. Jonathan apples grown in 16 orchards in Kent county, Michigan were selected for study of storage qualities.

REVIEW OF LITERATURE

Most reports of the influence of nutritional factors upon the keeping quality of tree fruits have dealt with the effects of nitrogen, potassium and boron.

Best overall keeping quality during storage, according to Eaves (13) was associated with leaf nitrogen values below 2.1 percent for the McIntosh and Northern Spy varieties. Hill, et al. (19) concluded that the highest quality was generally associated with medium or low nitrogen levels in the foliage.

Flesh softening of the fruit at harvest and during storage has been widely used as a measure of fruit quality with variable results being reported. For example: Magness and Overley (22), Weinberger (27),

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and Degman (10) found no significant differences in firmness at harvest or during storage for fruit grown under different rates of nitrogen application. Nitrate applications in August, according to Aldrich (1), caused a slightly greater flesh softening of York Imperial apples during storage, but did not affect the varieties Stayman Winesap and Rome Beauty. Another year's results showed no effect on any of the varieties.

Smock and Boynton (24), on the other hand, increased nitrogen applications and associated a decrease in fruit firmness and a greener ground color of the harvested fruit with the highest nitrogen level. Blasberg (8), testing foliar applications of urea, showed that fruit from sprayed trees were less firm than fruit from trees fertilized with nitrogen through the soil. Weeks, et al. (26) have reported that apple trees with a high nitrogen level gave the softest fruit; those with a low nitrogen supply had the hardest fruit at harvest.

Contradictory evidence for the influence of potassium on fruit firmness is available. Weinberger (27) reported no effect of potassium on firmness at harvest when applications were varied from 2.5 to 10 pounds of potassium chloride per tree. Overley and Overholser (23) demonstrated an increase in firmness with increased potassium applications, but there was a corresponding decrease in fruit size which probably affected firmness. Deficiencies of potassium for apples and peaches tended to make both kinds of fruit more firm at harvest-time, but caused a more rapid softening in storage, according to Beaumont and Chandler (7).

More rapid softening of the flesh of Jonathan, as well as other varieties of apples in storage, was observed by Batjer and Haller (6) to be related to the application of borax in the orchard.

Other characteristics studied to determine changes in keeping quality of the fruit have included metabolic activity and tissue constituents.

Haynes and Archbold (18) studied the effect of the nitrogen level upon the respiratory consumption of carbohydrates and acids in the harvested fruits. The loss of total sugars, alcohol insoluble residues, and acids (as malic acid) per unit of nitrogen was constant, although the absolute values varied widely. This confirmed a previous suggestion by Archbold (4) that high nitrogen values in the fruit are usually associated with a high respiratory activity. Smock and Boynton (24) also present evidence for higher respiration rates for apples with a high nitrogen content.

However, Gourley and Hopkins (14) increased the nitrogen content of apple fruits with increased amounts of nitrogen fertilizers, but found no correlation to an increase in the respiration activity of the fruit. They also found no effect on the specific gravity and acidity of the fruit juices as a result of increased nitrogen levels. The findings of Blasberg (8) showed that fruit from trees sprayed with urea had a lower level of soluble solids than fruit from unsprayed trees, but there was considerable seasonal variation.

The Jonathan apple, being susceptible to several serious storage disorders, has been observed in this respect to fertilizer practice. During three storage seasons Gourley and Hopkins (14) found no differences in the occurrence of storage disorders as a result of variations in nitrogen application. Degman (10) found no consistent association of fruit breakdown in storage with fertilizer practice, but other orchard practices, such as pruning and irrigation, sometimes resulted in excessively large fruit which were susceptible to storage breakdown.

Batjer and Haller (6) found that Jonathan apples from borax plots, when removed from storage in January and post-ripened at 70° F. for one week, had 50 percent spoilage from breakdown and decay, whereas check fruit had only 20 percent. Quite similar results were reported by Wilcox and Woodbridge (28) who defined the optimum range of boron content in the apple fruit to be 7 to 24 p.p.m. on a dry weight basis. Fruit containing boron in excess of this range invariably showed a considerably higher percentage of water core which, according to the authors, was a frequent point of origin of breakdown.

Brooks and Fisher (9) noted that apples from unfertilized plots developed internal breakdown, whereas fruit of fertilized plots was free of it. They also associated the occurrence of water core in the fall with the development of internal breakdown in storage, particularly in the largest apples.

Gourley and Hopkins (15) found that ample moisture conditions during the last few months of the growing season favored the development of breakdown, whereas a moisture deficiency resulted in firm, small apples which were seldom affected. Heavy pruning, a light crop, and over-maturity seemed to favor the trouble. No consistent relation was found between nitrate fertilizer applications and decay and breakdown. According to Overley and Overholser (23), breakdown development depended upon the season, but fertilizer treatments were of influence. Plots with potassium applied alone or combinations of phosphorus and other nutrients reduced breakdown in years in which

the fruit showed medium or great susceptibility to the disorder. Nitrogen applied alone clearly promoted the disorder. The effect of fruit size was not considered and might have been a factor.

Evidence for a relationship of nutrient status or fertilizer applications and the incidence or development of Jonathan spot was not found in the literature reviewed.

METHODS AND MATERIALS

Sixteen well-managed orchards in an area of similar climatic and soil conditions were selected in Kent county. The range of nutritional conditions was primarily dependent upon variation in fertilizer practices used by the growers. Deficiency symptoms were neither visible nor had been reported previously in any orchard. Five trees, uniform in appearance and typical of the orchard, were selected for the tests.

All orchards were under sod cultivation with additional organic matter supplied in most cases as mulch or manure. Soil applications of fertilizer during the test period varied from none to relatively heavy applications of a complete fertilizer each year. Foliar applications of urea were made on one-half of the orchards in 1956, none in 1957.

Leaf samples from the periphery of the trees were collected August 3 and 4, 1956 and July 27, 1957, and immature fruit samples (15 to 20 fruits) were taken June 20 and 22, 1957. Harvest occurred October 5 to 7, 1956 and September 28 to 30, 1957. One bushel of apples was picked from each tree for each of the two storage conditions. Samples for mineral analysis and quality evaluation prior to storage were taken at harvest in 1956 and several days before harvest in 1957. Fruit for respiration determinations came from the lots picked for storage. Regular storage at approximately 35°F. and 85 to 90 percent relative humidity was of five months duration in a grower-operated storage. Controlled atmosphere storage for seven months at 32° F., 2.5 percent carbon dioxide, 3 percent oxygen, and 90 to 95 percent relative humidity was in an experimental chamber at the University.

Quality evaluations were based on measurements of flesh firmness with the pressure tester using a $\frac{7}{16}$-inch plunger, ratings of the ground color using the Cornell color chart (25), soluble solids content of the fruit juice with a hand refractometer, and observations of surface and internal defects of the apples. Shelf-life of the fruit following storage

was observed upon holding at 75°F. Respiration behavior was measured by carbon dioxide evolution at 75°F.

The analyses of the leaves and fruits were made by the Department of Agricultural Chemistry.[2] Nitrogen was determined by the Kjeldahl method, potassium on the flame photometer, and phosphorus, calcium, magnesium, iron, manganese and boron on the spectrograph by the modified spark method (3). The calcium contents of the fruits of the second year's test were determined by complexometric titration of calcium plus magnesium with ethylenediaminetetraacetic acid and subsequent subtraction of magnesium as found by spectrographic analysis.

Correlation analyses were applied to the survey data, and the t-test with non-paired variables was utilized for testing differences between the treatments. Data with numerous zero values or showing seriously skewed distribution curves were transformed by $\sqrt{x + \frac{1}{2}}$ (Bartlett, 5) prior to analysis.

RESULTS AND DISCUSSION

Leaf and Fruit Analyses

Leaf and mature fruit composition values for 1956 and leaf, immature fruit and mature fruit values for 1957 are given in Table 1.

The average, high and low values for leaves in both years for the most part were similar to those obtained by Kenworthy (21) for Jonathan in Michigan. Potassium levels in one orchard (Number 4) were slightly below the optimum nutrient level both seasons when plotted on the nutrient element balance chart (20). This orchard had not been mulched and had received only nitrogen fertilizer. While leaf potassium values generally were higher in 1957 than in 1956, the reverse situation existed for the leaf contents of calcium and magnesium. Neither of the latter two elements was present in excessive or deficient quantities, however. Considerable seasonal variations also occurred for iron and boron.

Immature fruits contained considerably less calcium, magnesium, iron and manganese than the leaves. For other nutrients, immature fruits were comparable to leaves. The mature fruits were found to contain less of all nutrients, except boron, than the leaves.

The relationships of the leaf and fruit contents, as correlated on a tree basis, are shown in Table 2.

[2]The assistance of Dr. E. J. Benne and Mr. S. T. Bass in the chemical and spectrographic analysis of leaf and fruit samples is gratefully acknowledged.

TABLE 1—Nutrient-element composition on the dry weight basis for leaves and fruits of Jonathan apple trees

Year	No. of orchards	Value	N (%)	P (%)	K (%)	Ca (%)	Mg (%)	Fe (%)	Mn (p.p.m.)	B (p.p.m.)	Cu (p.p.m.)
						Leaves					
1956	16	Av.	2.20	.20	1.49	1.46	.40	.016	67	28	18
		High	2.58	.25	1.84	1.79	.55	.024	142	42	23
		Low	1.84	.16	0.95	1.05	.32	.012	27	17	14
1957	16	Av.	2.15	.21	1.62	1.18	.36	.022	58	39	19
		High	2.42	.25	1.97	1.45	.46	.038	129	61	25
		Low	1.82	.17	1.16	.96	.32	.013	25	21	17
						Immature fruits					
1957	14	Av.	1.69	.21	1.64	0.27	.18	.006	16	35	14
		High	2.15	.23	1.82	0.31	.20	.010	32	54	17
		Low	1.39	.17	1.24	0.22	.14	.004	10	21	12
						Mature fruits					
1956	6	Av.	0.29	.06	0.87	0.05	.04	.001	6.2	37	6.8
		High	0.39	.08	1.00	0.06	.05	.001	7.7	62	8.2
		Low	0.23	.04	0.68	0.04	.03	.001	5.3	20	6.3
1957	16	Av.	0.31	.09	0.91	0.06	.05	.004	4.3	62	4.2
		High	0.44	.10	1.05	0.07	.05	.006	7.0	79	4.9
		Low	0.23	.06	0.75	0.05	.04	.002	3.1	41	3.2

Highly significant correlations were consistently obtained between leaves and fruits for nitrogen, phosphorus, potassium and manganese. The values for calcium and copper were non-significant, indicating the leaf and fruit values either were not related or too variable in these tests to show a relationship. The fruit samples in 1957 were selected prior to harvest from the areas of the trees where the leaves

TABLE 2—Relationships of the nutrient-element contents of the fruits to the leaves and for fruits and leaves by years as expressed by correlation values

Correlation	Year	No. of trees	N	P	K	Ca	Mg	Fe	Mn	B	Cu
Mature fruits to leaves	1956	18	.741**	.732**	.768**	N.S.	.550*	N.S.	.547*	N.S.	N.S.
	1957	83	.394**	.423**	.668**	N.S.	N.S.	.255*	.779**	.250*	N.S.
Immature fruits to leaves	1957	70	.737**	.333**	.680**	N.S.	N.S.	N.S.	.678**	N.S.	N.S.
Mature fruits to immature fruits	1957	70	.521**	N.S.	.517**	N.S.	N.S.	N.S.	.579**	N.S.	N.S.
1956 to 1957 (Leaves)	—	—	.809**	.724**	.753**	.510*	.663*	N.S.	.819**	N.S.	N.S.
1956 to 1957 (Mature fruits)	—	—	N.S.	.322**	.431**	N.S.	N.S.	N.S.	N.S.	.409*	N.S.

* Statistically significant at the 5% level.
** Statistically significant at the 1% level.

were taken to eliminate some of the variability. This may account for the significant correlation values for iron and boron obtained only in 1957.

Correlations by years were higher and of significant value for more elements for leaf composition than for mature fruit composition. Evidently, leaf analyses are a better guide to the nutritional status of these orchards than fruit analyses since the fertilizer programs for both years were similar for each given orchard.

Quality Characteristics

The average values for flesh firmness, ground color of the skin, and soluble solids content of the extracted juice of the flesh of the fruit are given in Table 3.

TABLE 3—Flesh firmness, skin ground color, and soluble solids content of the juice of Jonathan apples

Time of examination	Flesh firmness		Ground color		Soluble solids	
	1956	1957	1956	1957	1956	1957
	(lbs.)	(lbs.)	(rating)	(rating)	(%)	(%)
At harvest	20.8	20.3	2.7	2.6	14.2	13.9
After regular storage (5 mos.)	14.9	15.5	1.5	1.7	14.1	13.4
After C-A storage (7 mos.)	16.3	16.4	1.8	1.9	14.5	13.4

Softening of the flesh and yellowing of the skin were retarded by controlled atmosphere storage as compared to regular storage even though the C-A storage period duration was two months longer. Soluble solids contents were variable, declining slightly in regular storage and increasing slightly in C-A storage in 1956-1957, and decreasing 0.5 percent from harvest in both storages in 1957-1958.

The fruit were of approximately equal average firmness each year at harvest and softening in storage was similar in the two seasons. There was, however, no correlation in firmness for fruit harvested from the same trees for the two years. Fruits from trees which were relatively firm or soft at harvest-time, were also relatively firm or soft, respectively, after storage in the regular and controlled atmospheres.

Fruit firmness was inversely associated with nitrogen content of the fruit in 1957, but not in 1956 when a limited number of fruit

analyses were made. Significant negative associations between the firmness of the fruit at harvest and the nitrogen content of the leaves occurred in both years.

Since there was no effect of size upon firmness, it is evident that increased nitrogen directly resulted in a softer flesh, rather than indirectly because of larger fruit size. No effect of nitrogen upon rate of softening during storage was noted.

No consistent relationship of firmness to nutrient content of either leaves or fruits were noted for the other elements studied.

The nutrient-element contents of the leaves and fruits were of no effect upon ground color.

In both seasons the soluble solids of the fruit juice were negatively associated with the nitrogen and phosphorus contents of the fruit. Potassium was negatively associated with soluble solids in 1956, boron in 1957. The leaf nitrogen content, however, showed an inverse association only at the 5 percent level in 1956, and the leaf potassium and soluble solids values were unrelated both years.

A highly significant association existed for soluble solids and the incidence of water core in the fruit at harvest-time.

Storage Disorders

Internal breakdown in storage and upon holding at 75° F. after removal from storage was of minor extent for all orchards in 1956 and for most orchards in 1957. The fruit from several orchards in 1957, however, became seriously affected. The trees producing fruit with the highest incidence of this disorder had fruit potassium contents considerably lower than the fruit from the trees yielding small quantities of fruit susceptible to breakdown. None of the other nutrient values were related to the occurrence of this defect, nor was the magnesium-calcium ratio of the fruit contents related. Comparisons by fruit size, water core, and flesh firmness were made. Affected and non-affected lots of apples differed significantly only in fruit size, with the lots of larger size (154 fruits vs 174 fruits per box) being more susceptible. Within a susceptible lot of apples, however, the development of breakdown during storage was not limited to the larger-sized fruit. A greater susceptibility of apples to internal breakdown because of low potassium and large size has been reported by other investigators (9, 23). A seasonal effect upon breakdown has been shown by Haller and Lutz (17), and during the first year of this test,

the excellent growing conditions may have compensated for any adverse effects of nutrient unbalance so that practically no breakdown development was observed in that season.

As previously shown by Dewey, et al. (12), controlled atmosphere storage does not prevent the development of internal breakdown in susceptible fruit of the Jonathan variety. Slightly greater amounts of breakdown found here in susceptible lots of apples stored in C-A than in regular storage are attributed to the longer storage period of the C-A apples. It is obvious that fruit for controlled atmospheres should be selected from trees and orchards with a history of freedom from this disorder.

Although Jonathan spot is prevented by controlled atmosphere storage, a related skin discoloration is evidenced frequently which had been previously considered to be a controlled atmosphere storage disorder (12). In these studies, skin discoloration which was apparently caused by a change in color of the anthocyanin pigments from red to bluish-brown and purplish-brown was found on apples in regular storage as well as in controlled atmosphere. The occurrence of both types of skin disorders for the 1957-1958 season are summarized in Table 4. In most orchards, the five test trees produced a fairly uniform percentage of fruit susceptible to Jonathan spot and skin discoloration. Comparison of the data for the two seasons showed these skin disorders were dissimilar in occurrence by orchards, and no significant correlation was found for the susceptibility of individual trees for the two years. A significant association of Jonathan spot to fruit potassium existed in 1957; otherwise, no relationship of mineral content of the fruit to skin disorders was evident. The average occurrence of skin discoloration during controlled atmosphere storage was not significantly different from that on apples in regular storage, and its occurrence by trees and orchards in the two storages was similar.

Evidently, the fruit was predisposed to Jonathan spot and/or skin discoloration at harvest-time by environmental factors other than nutrition; its subsequent development was affected by storage method.

The respiratory activity of the fruit of several orchards was determined at 75° F. to ascertain the maturity of the apples at harvest and to compare the effects of storage method upon fruit behavior. Apparently, all fruits were picked post-climacteric since none of the lots showed evidence of the climacteric rise in carbon dioxide evolution reported for Jonathan by Haller and Lutz (16). All fruit showed a gradual decline in carbon dioxide production during the 10-day test

TABLE 4—Percentages of fruit with Jonathan spot and skin discoloration upon removal from regular and C-A storage by orchards, 1957-58

Regular storage				C-A storage
Jonathan spot	Jonathan spot and discoloration	Discoloration only	Total	Discoloration only(*a*)
2	1	1	4	1
4	1	0	5	2
5	0	0	5	0
3	1	2	6	6
6	0	0	6	0
7	0	1	8	2
7	0	1	8	1
10	0	2	12	1
13	0	1	14	1
14	0	0	14	2
14	0	1	15	2
14	0	2	16	10
20	0	5	25	0
21	1	4	26	11
33	0	7	40	3
11	0	33	44	27
38	0	11	49	9

(*a*) No Jonathan spot on C-A fruit.

period. In most instances apples after regular storage for five months had lower respiration rates than apples stored for seven months in C-A storage, which is further evidence that less ripening and deterioration occured during the longer C-A storage period than during regular storage.

The wide range in respiratory activity of the fruit from different orchards at harvest suggested there might be differences in storage response of the fruit. This proved to be true for the incidence of internal breakdown, and as shown in Table 5, apples with the highest rate of carbon dioxide production at harvest were from an orchard which yielded fruit that was very susceptible to the development of internal breakdown. Contrary to some reports (4, 18, 24), the higher respiration was not associated with a higher nitrogen level in the fruit and leaves. The lowest potassium in the leaves and fruits accompanied the highest respiration rate and largest quantity of breakdown. Further study of this relationship is needed before any conclusion can be drawn. Although Degman and Weinberger (11) could find no relationship between potassium shortage and respiration of the fruit in storage, it has been demonstrated by Amberger (2) that potassium

TABLE 5—Respiratory activity of Jonathan apples at harvest in relation to nitrogen and potassium contents of the leaves and fruits and to the development of internal breakdown, 1957-58

Orchard (number)	4	7	2	9	3
Respiration of fruit (mg. CO_2/kg. hr.)	38	33	30	29	28
Internal breakdown (%)					
At end of storage	16.5	1.9	3.9	0.0	0.1
After 10 days at 75° F.	60.5	11.0	27.0	0.0	14.5
Potassium (%)					
Leaves	1.16	1.46	1.37	1.50	1.55
Immature fruit	1.24	1.49	1.26	1.68	1.72
Mature fruit	.75	.92	.83	1.01	.91
Nitrogen (%)					
Leaves	2.31	2.06	1.82	2.21	2.42
Immature fruit	1.78	1.46	1.39	1.58	1.99
Mature fruit	.34	.31	.28	.35	.40

directly influences the respiratory enzymes of some leafy crops. According to Amberger, increased quantities of potassium inhibited the activity of the respiratory enzyme and thereby reduced respirational losses of stored materials. Overley and Overholser (23) have reported reductions in the incidence of internal breakdown as a result of increasing potassium fertilization.

SUMMARY

The 16 Jonathan apple orchards in Kent county, Michigan, used in these tests were found to be within the levels of nutrition that are normally considered optimum for this variety as determined by leaf analysis. The nutrient-element contents of the mature fruits were considerably lower than of the leaves for all nutrients except boron. The nutrient content of immature fruit was lower than the leaves for calcium, magnesium, iron and manganese.

There were highly significant positive correlations during both years for leaf and fruit contents of N, P, K and Mn; whereas the Ca and Cu of the leaves and fruits were not correlated. The correlation values for the two years showed that leaf analysis was influenced less by season than fruit analysis.

Controlled atmospheres of 2½ percent carbon dioxide and 3 percent oxygen at 32° F. for seven months proved superior to storage for five months in regular air at approximately 35° F. Fruit ripening,

as measured by softening and yellowing of the ground color, was least in the controlled atmospheres and Jonathan spot was completely inhibited. Internal breakdown, when present, was more extensive in C-A than in regular storage.

Flesh firmness was affected only by nitrogen. The softest fruit at harvest was associated with a high nitrogen content of the leaves and fruits in 1956 and of the leaves in 1957. Differences in ground color of the epidermis of the fruit were not related to nutrient contents. Fruits with highest soluble solids had low values for nitrogen and phosphorus in both years, low potassium in 1956, and low boron in 1957. Leaf contents, other than low nitrogen in 1956, were not related to soluble solids of the extracted fruit juices.

Internal breakdown occurred in the fruit from several orchards in regular and C-A storage in 1957. The apples of these orchards were low in potassium and had a higher respirational activity at harvest than fruit from orchards that were not susceptible to breakdown development.

Jonathan spot occurred in regular storage without any consistent association to nutrient factors. Although spot was prevented by C-A storage, a bluish or purplish-brown discoloration of the anthocyanin-bearing epidermal tissues frequently developed on lots of fruit comparable to the lots having excessive spotting in regular storage. This discoloration also appeared in regular storage and usually on apples that were also affected with Jonathan spot.

These studies show that differences in nutrient contents of the leaves and fruit within the optimum ranges for good growth and yield did not affect markedly the storage quality of the fruit. An exception was potassium, in that the low levels found here were associated with an increased amount of internal breakdown in the one year it was evident. Further study is being made of this relationship, together with the respiratory behavior of the fruit.

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SOIL AND AIR TEMPERATURE AS AFFECTED BY POLYETHYLENE FILM MULCHES

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SOIL MULCHES OF LEAVES, straw, and sawdust have long been used for weed control and moisture conservation on horticultural crops. Black paper, although it possesses an added characteristic of raising soil temperatures, has never been used widely (Rowe-Dutton, 1957). High material and labor costs, in addition to their influence on nitrogen availability resulting from the decomposition of these carbonaceous materials, have limited their use.

In recent experimental and commercial tests black polyethylene has shown considerable promise as a mulching material for high value crops. Plastic film, usually 1.5 to 2.0 mils in thickness and 2 to 4 feet wide, is laid over the soil, and seeds or transplants planted through slits made at desired intervals. Melons, snap beans, tomatoes, and other crops grown through a black plastic mulch have often matured earlier and produced higher yields (Emmert, 1957; Carolus and Downes, 1958). These responses have generally been attributed to the soil warming effects of the plastic. Reductions in labor for cultivation and weed control have been attained by the use of polyethylene.

This increased use of plastic film in vegetable production warranted an interest in the effects of various types of plastics on the temperature of the soil beneath the covers as well as their effects on air temperatures above and below the plastics. Presently, limited data of this nature are available (Eggert, 1958; Voth and Bringhurst, 1959). Nor are the authors aware of any published data concerning the effects of plastics on early morning soil surface temperatures to determine if they might influence frost damage.

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MATERIALS AND METHODS

These studies were made in two locations during successive seasons. The first was made on organic soil at the Michigan State University Muck Experimental Farm during May and June, 1957. Two 50-foot lengths of 1.5 mil black polyethylene film were laid over the soil. Thermocouples were placed in the following positions: (1) At a 5-inch depth in the soil beneath the plastic; (2) at a 5-inch depth in bare soil; (3) ¼ inch above the plastic surface; (4) ¼ inch above bare soil; and (5) 12 inches above the bare soil. Temperatures were measured and recorded with a potentiometer and multipoint strip chart recorder.

The second study was made on mineral soil at the Michigan State University Horticultural Farm from May 8 to June 4, 1958. Four plastic film coverings were used: (1) 2.0 mil black polyethylene, (2) 2.0 mil black polyethylene used as a hood supported by wire hoops 8 inches high and 2 feet wide spaced 2 feet apart, (3) 2.0 mil black polyethylene with the upper surfaces painted white[2], (4) 2.0 mil aluminum pigmented polyethylene. Thermocouples were placed at a 3-inch depth in the soil beneath each cover, in the air spaces between the covers and the soil surface, and ½ inch above the surface of each plastic except the white-surfaced. Thermocouples were also placed in bare soil at a depth of 3 inches, ½ inch above the bare soil surface, and in the air. The latter thermocouples were placed in a shaded place. Temperatures were measured and recorded with a potentiometer and multipoint strip chart recorded. A view of the set-up is shown in Fig. 1. The data presented in Figs. 4, 5, and 6 are a mean of temperatures for 15 sunny days when 24-hour records were obtainable with all thermocouples.

RESULTS AND DISCUSSION

Soil temperatures on muck for a typical June day as affected by the black polyethylene film covering are shown in Fig. 2. Temperature of the covered soil, measured at a depth of 5 inches, averaged 2.5° F. higher than that of the bare soil. At this soil depth, the maximum temperatures lagged behind the maximum air temperature by 4 hours, while daily lows lagged by 8 hours. A similar relationship between time of day and soil temperatures existed on sunny and cloudy days.

Temperatures above the surface of bare and covered soil of 8

[2]Furnished by the Bakelite Company.

Fig. 1. Polyethylene coverings used for studying temperature effects. Thermocouples lead to potentiometer-recorder in the shelter at right.

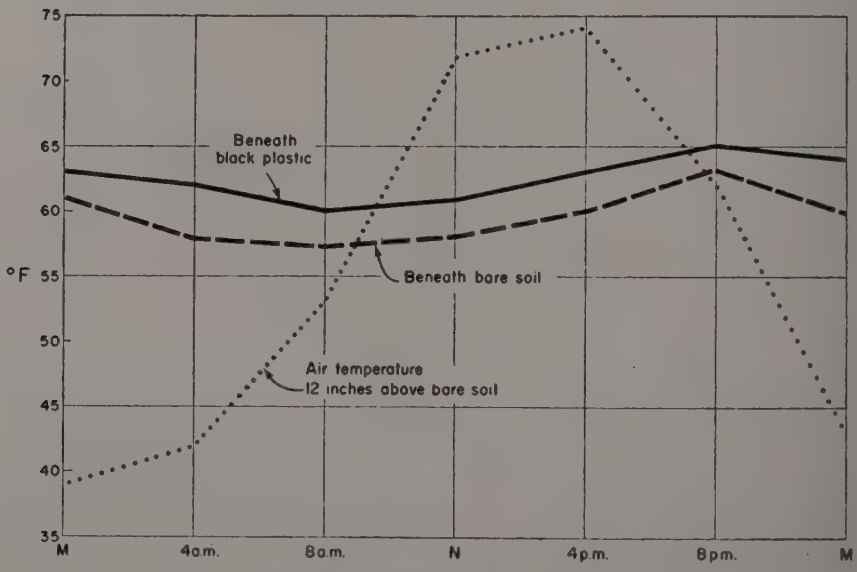

Fig. 2. Soil temperatures at 5-inch depth of bare and black plastic-covered muck soil for typical day (June 8).

consecutive days are shown in Fig. 3. During the early morning, 4 to 6 o'clock, when frost damage most often occurs, the air temperatures adjacent to the upper surface of the black plastic averaged one degree warmer than the air near the bare soil. During this period air temperatures ¼ inch above the covered and uncovered soil and 12 inches above uncovered soil were within 1 degree of each other. After sunrise the air temperatures near the two surfaces rose more rapidly than the air temperature 12 inches above the soil.

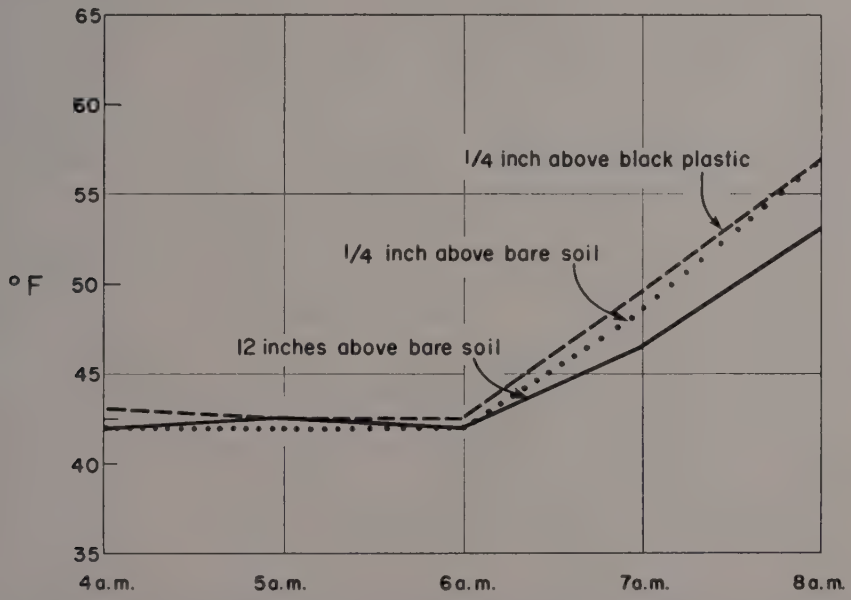

Fig. 3. Early morning air temperatures above bare and plastic-covered muck soil. (Mean of 8 consecutive days June 8-16.)

Mineral soil temperature averages at a 3-inch depth below plastic films are shown in Fig. 4. Night temperatures of the covered soils were several degrees higher than that of the bare soil. At 4 a.m., when the lowest temperatures were recorded, the temperature of the soil covered with black plastic was 3 degrees higher than the uncovered soil. Temperatures of other plastic coverings ranged between those for the black film and the uncovered soil. Temperatures, on sunny days, of the covered soils were lower than the exposed soils. During the hours from noon to 4 p.m., the soil beneath the black plastic hood

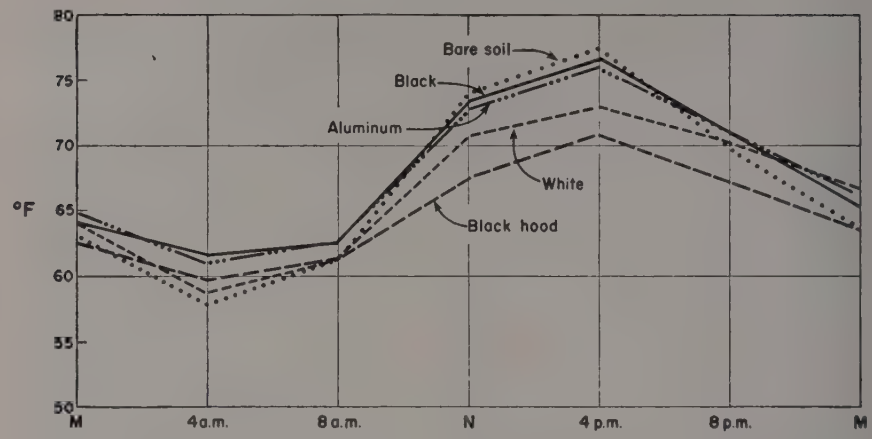

Fig. 4. Mean soil temperatures for 15 sunny days 3 inches below surface of exposed and covered mineral soil.

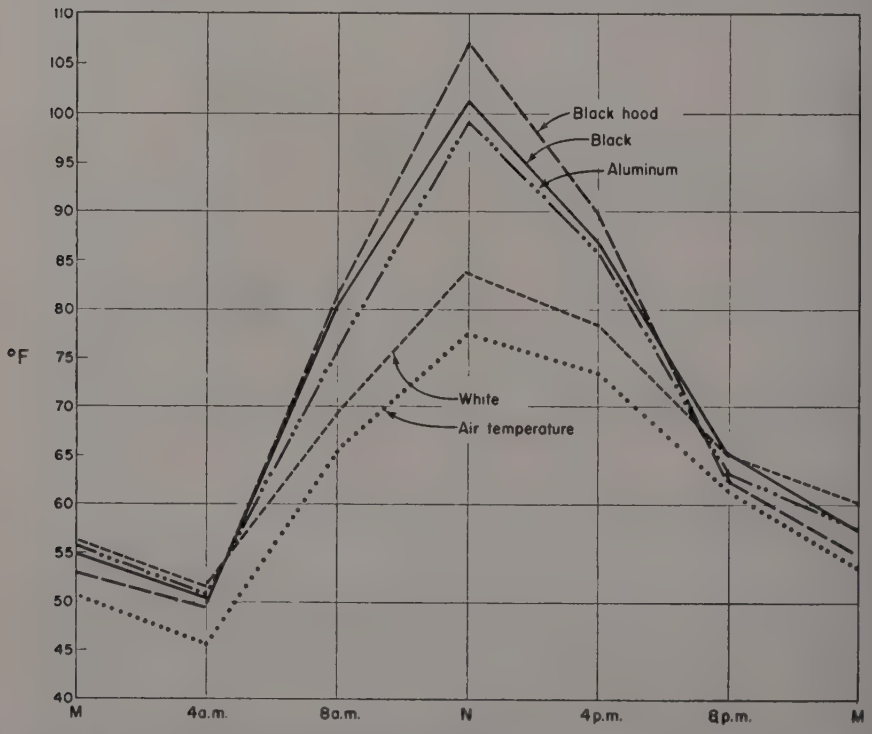

Fig. 5. Mean air temperatures for 15 sunny days above exposed area and between film and soil surface of covered mineral soil.

remained about 5 degrees cooler than the uncovered soil with intermediate temperatures occurring beneath the other plastics. Temperature of the soil beneath the black plastic hood showed less fluctuation. The lowest and highest soil temperatures generally occurred about 4 a.m. and 8 p.m., respectively.

The temperature effects of plastics on the mineral soil did not coincide closely with those found for muck soil. The marked differences in color and texture of the two soils might be responsible. In addition, the thermocouples on the mineral soil were placed 2 inches nearer the soil surface.

Average air temperatures beneath the various plastic coverings are shown in Fig. 5. During the period 8 a.m. to 4 p.m., on sunny days, the highest temperature was recorded for the air within the hood of black film. It was 30.4° F. higher at noon than air 12 inches above the soil. Air temperatures beneath the black and aluminum coverings were lower than beneath the black hood. The aluminum plastic maintained an average temperature 1 degree lower than the black. The comparatively high air temperature beneath the plastic hood coin-

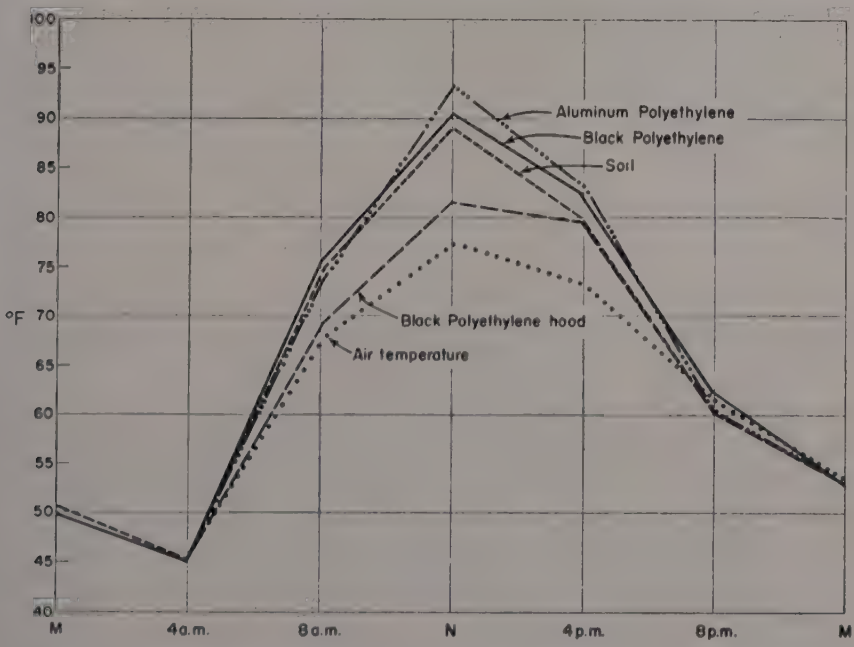

Fig. 6. Mean air temperatures for 15 sunny days ½ inch above surface of exposed area and above the film of covered mineral soil.

cident with a lower soil temperature cannot be reconciled by these data. The white-surface plastic maintained the lowest air temperature of all the coverings during the 8 a.m. to 4 p.m. period of the day, averaging 5 degrees above the air temperature during this period.

Mean air temperatures ½-inch above the surface of various soil coverings are shown in Fig. 6. Average surface temperatures were similar during the early morning hours. At 4 a.m. the air temperature was 45.2°F. The temperature of the soil surface at this hour was 46.1°F., and the surface temperatures of all the plastic coverings fell within 0.2 degree of the air temperature. The surface temperature of the black and the aluminum covers at noon were higher than the soil surface, 3.6 degrees higher for aluminum, 1.1 degrees higher for the black. The surface temperature of the black plastic hood was 7.6 degrees cooler than the soil surface at the same time of day. Temperatures of the white plastic surface were not obtained.

Comparisons of temperatures beneath the various plastics on a warm, sunny day and a cool, cloudy day are shown in Figures 7 and

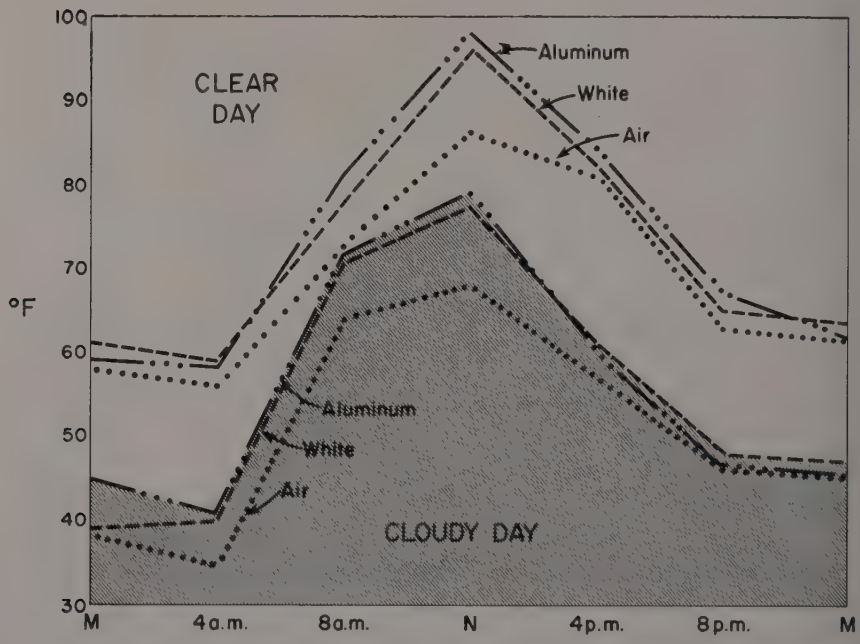

Fig. 7. Temperatures of air between film covers and mineral soil for a warm and clear day and a cool and cloudy day.

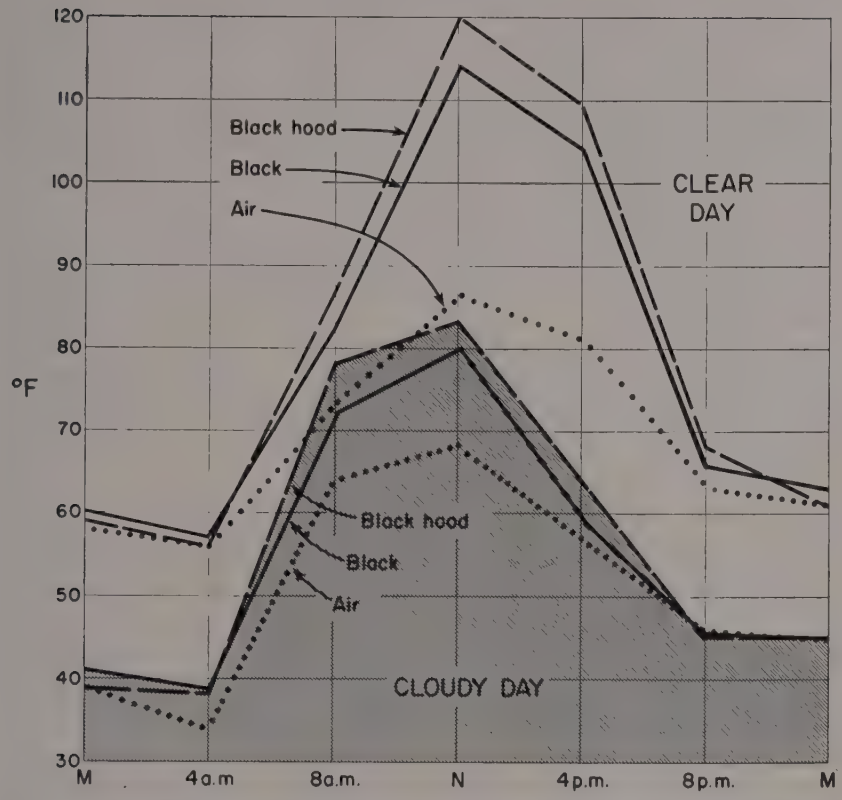

Fig. 8. Temperatures of air between film covers and mineral soil for a warm and clear day and a cool and cloudy day.

8. The relative temperatures under the various coverings were considerably different for the two conditions, however, their relationships to each other were of similar pattern. Temperatures beneath the white-surfaced and the aluminum plastics on the warm clear day (Fig. 7) illustrate the effect of heat-reflecting surfaces. These two light-colored films maintain a much lower under-cover temperature than the black.

SUMMARY

Muck soils covered with black polyethylene film had average temperatures at a depth of 5 inches which were 2.5 degrees F. warmer than uncovered soil at the same depth. Early morning temperatures

(4 to 6 a.m.) of the air ¼-inch above the black plastic averaged ½ to 1 degree higher than air temperatures above bare soil.

Soil and air temperature effects were determined for coverings of black polyethylene, black polyethylene hood, white surfaced black polyethylene, and aluminum colored polyethylene on mineral soils. Night temperatures of the soil beneath the plastic films were higher than the uncovered soil. During the daytime bare soil temperatures were higher than the soil beneath the films. Early morning air temperatures ½-inch above the plastics were no higher than comparable air temperatures above bare soil. Air temperatures below the black and the aluminum colored plastics averaged 10 to 30 degrees higher than outside air temperature during daylight hours. The higher air temperatures beneath the white-surfaced plastic ranged within 5 degrees of the air temperature.

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SYSTEMATIC SAMPLING APPLIED TO ESTIMATING THE AVERAGE NUMBER OF ACRES PER FARM IN BARRY COUNTY, MICHIGAN

By WILLIAM DOWELL BATEN[1]

IN PREVIOUS ARTICLES (Baten 1956, 1957, 1958, 1958) on sampling applied to estimating the average number of acres per farm in Barry county, Michigan, the author discussed random, optimum, stratified and two-stage sampling and showed that averages obtained by these methods of securing information gave good estimates of the real average that had rather small measures of dispersion. In this article systematic sampling will be presented with comparisons of other methods.

It is important to be able to secure representative data about the universe from which a survey is being conducted. Samples are to be chosen in such a way that every item in the universe has an equal chance of being chosen. Considerable thought can be used profitably in planning a survey and carefully worked out designs in advance of any sampling will prove to be worthwhile. One way of gathering information from a universe is to use systematic sampling. A systematic sample is obtained by taking, for a 8⅓ per cent sample, every twelfth item in the universe; in the case considered here, every twelfth farm in the county which had been numbered for each township. In Barry county there were 4,249 farms which were numbered from 1 to 4,249. The last farm was omitted to make 4,248. To be able to find a starting place it is necessary to select at random some number less than 13, which can be expedited quickly by using a table of random numbers found in many statistical texts or by drawing one ticket, at random from a box, in which there are 12 tickets numbered from 1 to 12. If the number 4 is drawn the fourth farm in the county is taken as the starting place and the sample includes the

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4th, 16th, the 28th farm, and so on. If the number 9 is drawn every 12th farm is taken for the sample; that is, the 9th, 21st, 33rd etc. are used to make up the 8⅓ percent sample. By choosing at random any number less than 13, every farm has an equal chance of being in the sample. In carrying out surveys, experts believe that systematic sampling leads to approximate universe values.

The number 2 was randomly chosen for the first sample; hence, the number of acres in the 2nd, 14th, 26th, etc. farms were used for this sample. The number 6 was drawn for the second 8⅓ percent sample; hence, the 6th, 18th, 30th, etc. farms were used.

The arithmetic average of a systematic sample is calculated by dividing the sum of the acres in all the farms in the sample by the number of items in the sample or the number of farms or

$$(1)\quad \bar{y}_{sy} = \sum_{i=1}^{354} y_i \,/\, 354 \quad ,$$

since 1/12 of 4,248, the number of farms in the county, is 354. For the two systematic samples chosen the averages are respectively

$$\bar{y}_{sy} = 79.21 \text{ acres and } \bar{y}_{sy} = 76.93 \text{ acres.}$$

The variance of the average of a systematic sample is

$$(2)\quad \sigma^2_{\bar{y}_{sy}} = \sum_{i=1}^{k} (n\bar{y}_{i.} - n\bar{y})^2 \,/\, n^2k$$

where n is the number of items in the sample, $\bar{y}_{i.}$ is the average of the i^{th} systematic sample, k is the number of possible systematic samples that can be drawn from the universe and $\bar{y}$ is the average of the universe. In our case $n = 354$, $k = 12$, $\bar{y} = 80.19$ acres and the values of $\bar{y}_{i.}$ are given in Table 1 (Cochran 1953).

To be able to use this formula it is necessary to know the average of every systematic sample that can be selected and the real average for the county. If the real average number of acres per farm for the entire county is known it is not necessary to sample and hence, formula (2) is not very useful. Results will be found from several systematic samples and compared with results from all possible samples, which of course leads to the true average.

Table 1 contains averages of the 12 possible systematic 8⅓ per cent samples together with estimates of the total number of acres in the county and their standard deviations.

TABLE 1—Arithmetic averages of 12 possible 8⅓ per cent systematic samples from Barry county, Michigan, with estimates of the total number of acres in the county and their standard deviations (acres)

Sample number	Average	Standard deviation of the average	Estimate of the total number of acres	Standard deviation of the total
1	77.36(*a*)	2.84	328,608(*b*)	12,074
2	79.21	2.85	336,504	12,123
3	83.68	2.87	355,464	12,199
4	79.33	2.75	336,972	11,706
5	85.51	3.04	363,240	12,945
6	76.93	2.69	326,796	11,449
7	79.81	2.52	338,904	10,693
8	78.38	3.02	332,940	12,813
9	78.91	2.94	335,208	12,512
10	83.03	3.46	352,704	14,687
11	81.26	2.69	345,204	11,406
12	78.96	2.71	335,400	11,516
True	80.19 Av.	2.87	340,662	Av. 12,177

(*a*) The standard deviation of each systematic sample averages, according to formula (2) is 2.53 acres.
(*b*) The standard deviation of each estimate total is 10,738 acres.

All of the .95 probability fiducial limits of the above averages, except one, using 2.53 acres as the standard deviation, contain the real average.

The .95 probability fiducial interval is found by adding and subtracting 2 (2.53) to the average; for example, this fiducial interval for the first sample average in Table 1 is equal to

$$76.93 - 2(2.53) \text{ to } 76.93 + 2(2.53) \text{ or}$$
$$71.87 \text{ acres or } 81.99 \text{ acres}$$

which contains the real average 80.19 acres.

No one is going to choose all possible systematic samples, but will only draw one or perhaps two. There is no formula for estimating the standard deviation of the mean of one systematic sample from only one sample Sukhatme (1954). Cochran (1953) gives estimates from only one systematic sample but they do not apply in the case considered here. One naturally would find the standard deviation of the one sample and consider that to be the standard deviation of this particular sample. On examining the third column of Table

1 it is seen that in every instance except one the standard deviation of individual samples is larger than the standard deviation of the systematic sample average.

Suppose only one 8⅓ per cent systematic sample is to be taken and it is No. 2 in Table 1. Divide this sample into six systematic samples each of 59 farms as

Totals.....	4792	4472	4164	5147	4599	4965
Averages.....	81.27	75.80	70.58	87.24	77.95	84.15

The variance between means is found as follows

$\sigma_{\bar{sy}}^2 = \sum_{i=1} (\bar{y}_{2,i} - \bar{y}_2)^2/6 = 30.07 = A$, which is the variance of any of the above systematic averages of 59 farms. The standard deviation between means of these 1/72 systematic sample averages is $\sqrt{30.07} = 5.48$.

The average of the second systematic sample of 354 farms is the average of the average of the above six systematic samples; hence, the standard deviation of the $\frac{1}{12}$ systematic sample average may be approximated by

$$\sigma_{Sy\,(354)} = \sqrt{6A/36} = \sqrt{1(30.07)/6} = 2.24 \text{ acres},$$

which will now represent an approximation to 2.53 acres found by using all twelve systematic sample averages in Table 1.

Suppose that the $\frac{1}{12}$ systematic sample averages is No. 6 in Table 1, that is 76.93, and that six systematic sample averages were obtained as in the previous case. An approximation for the standard deviation of the 6th $\frac{1}{12}$ systematic sample average is found to be 2.42 acres, which is smaller than the value 2.53 acres found by using all of the 12 systematic sample averages given in Table 1.

If each of the 8⅓ per cent systematic sample averages are divided into 6 systematic samples as explained above, the average of all the approximations to the standard deviation of the 12-8⅓ per cent systematic samples is found to be 2.29 acres and the range of these approximations is 1.40 acres to 3.39 acres.

The second 8⅓ per cent systematic sample was divided into three systematic samples and the standard deviation was found as when it was divided into six systematic samples. In the case of these samples an approximation for the standard deviation of the $\frac{1}{12}$ systematic sample average was found to be 1.95 acres.

When the sixth 8⅓ per cent systematic sample was divided into three systematic samples an approximation for the standard deviation of the mean of the $\frac{1}{12}$ systematic sample average was found to be 2.77 acres. Each $\frac{1}{12}$ systematic sample was divided into three systematic samples and approximations were found for the standard deviations for each 8⅓ per cent systematic sample averages. The averages of these approximations were found to be 2.22 acres where the range was from .45 acres to 4.53 acres where most of them were greater than 2.00 acres.

When systematic samples No. 2 and No. 6 were each divided into two systematic samples the standard deviations of the $\frac{1}{12}$ systematic samples were found to be 1.79 and 2.31, respectively. When all $\frac{1}{12}$ systematic samples were divided into two systematic samples and their standard deviations found, as explained above, the average of them was 1.42 where they ran from .43 — 3.09 with the majority of them less than 2. This shows that finding estimates of the $\frac{1}{12}$ systematic sample variances by using only two systematic samples of each is not adequate in this case.

If a random systematic sample is desired, it is suggested that since there is no formula for the standard deviation of only one systematic sample average that this sample be broken down into smaller systematic samples and the between means used to arrive at an approximation for the standard deviation of the single systematic sample average.

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SOIL TREATMENTS IN RELATION TO VERTICILLIUM WILT OF EGGPLANT

By DONALD J. deZEEUW and CLYDE L. BURTON[1]

DEPARTMENT OF BOTANY AND PLANT PATHOLOGY

VERTICILLIUM WILT OF EGGPLANT, caused by the soil-borne fungus *verticillium albo-atrum* Reinke & Berth., has produced heavy yield losses or even crop failures for many Michigan growers. Some farms are only partially infested with the fungus and the losses are less noticeable, especially where conditions are favorable to the crop. All growers who have learned to know the disease are interested in control. Since resistant varieties have not yet been developed some type of soil treatment offers most promise for the present.

In the course of a study on possible transmission of the fungus through eggplant seed[2] it was noticed that the disease was endemic in certain low areas of the Michigan State University experimental plots. Strawberry plantings on the same sites had also suffered from the disease. These areas were used, in lieu of artificial infestation, for the determination of effectiveness of several soil treatment fungicides against the disease.

MATERIALS AND METHODS

Plots for treatment were made 16 feet square with 3-foot buffer zones between them to avoid part of the cross-contamination and re-infestation that can follow soil treatment. In 1957 four materials were used in a duplicate randomization and one in a single plot. In 1958 four materials were tested in a four-replicate randomized block arrangement and three in single plots adjacent to the main block (Table 1). The per-acre rates of most materials were proportioned for the individual plots (256 sq. ft.) and the chemical applied in 25 gallons of water. Chloropicrin was injected with a "Fumigun" to a

[1]Assoc. Prof. and graduate student, respectively, Dept. of Botany and Plant Pathology.

[2]Burton, Clyde L., and Donald J. deZeeuw. 1958. Studies on transmission of *Verticillium* wilt of eggplant in Michigan. Pl. Dis. Reptr. (U.S.D.A.) 42: 427-436.

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TABLE 1—Materials, rates, active ingredients and suppliers of soil treatment fungicides used in the eggplant trials 1957-1958

Treatment number		
1957	1958	
1	3	*Chloropicrin* (Tech.). "Larvacide" brand Morton Chemical Co., Panogen Co. Div. 130 liters per acre.
2	–	*C-272.* Experimental 12½ per cent wettable power of trans-1,2-Bis (ethylsulfonyl) ethylene. Chemagro Corp. 25 lbs. per acre (active).
3	5	*CP-376.* Experimental 4 lbs. per gal. Emulsifiable concentrate orthonitrochlorobenzene. Monsanto Chemical Co. 80 lbs. per acre (active).
4	–	*Mylone.* Crag 974—90 per cent formulation of 3,5-dimethyltetrahydro 1,3,5,2H-thiadiazine-2 thione. Union Carbide Chemicals Corp. 270 lbs. per acre (active).
–	4	*Mylone.* Preplant-50—50 per cent formulation from W. H. Barber Co. 170 lbs. per acre (active).
5	1	*Control.* No chemical treatment.
6	2	*Urea-Formaldehyde.* "N-Dure" brand of Nitrogen Div., Allied Chemical Corp. containing Urea 25 per cent, Formaldehyde 50 per cent. 150 gal. formulation per acre.
–	6	*EP-131.* 97 per cent mixture. Experimental soil fumigant and fumigant sealer. Panogen Co. 340 lbs. formulation per acre.
–	7	*Chloropicrin.* (Tech.). Single plot treated as No. 3.
–	8	*Mylone.* Preplant 50. 340 lbs. per acre (active).

depth of 6 inches using 3 c.c. per injection on 12-inch centers. The injection holes were pressed shut immediately to prevent loss of the fumigant. Within the day all plots were additionally sealed with about ½ inch of irrigation water. After two weeks the plots were double tilled with a Howard Rotavator in preparation for planting. The treatments were applied in the last week of May and the planting with greenhouse-grown sets was completed on June 15. Sixteen plants 6 to 8 inches high were set in each plot using a starter solution.

On August 15, prior to the first picking, the plant height averages were determined by measuring the three tallest leaders of each plant in the plot. Numbers and weights of marketable fruit were taken at weekly intervals for six weeks beginning August 15. Disease incidence was determined by noting the number of plants with external symptoms characteristic of eggplant wilt (Fig. 1) and also by observing the number of plants with vascular browning characteristic of the disease. Occasional isolations were made to confirm the accuracy of diagnosis although visual symptoms had previously been found reliable.

Fig. 1. Early symptoms of Verticillium wilt of eggplant. Note the pale (or yellow) patches and partial wilting of leaves on right, left and lower center. This plant has a moderate infection, late in onset, that ordinarily will allow a partial crop but may not kill the plant before the end of the season.

EXPERIMENTAL RESULTS

The data from the 1957 treatments (Table 2) gave evidence of partial control of the disease as shown by the low incidence in the chloropicrin treated plots. Apparently the extra fertility given by the Urea-Formaldehyde concentrate masked some of the external symptoms of disease without effecting a real control since nine plants showed vascular browning. The plot variability was too great to allow final conclusions on yield but both chloropicrin and Urea-For-

TABLE 2—Eggplant soil treatments 1957. Height of plants, yield, and incidence of Verticillium wilt

	Treatment	Ht.(*a*)	Number fruit(*c*)	Disease averages(*c*)	
				External symptoms	Vascular browning
		in.			
1	Chloropicrin	20.4	68.5	1.0	2.0
2	C-272	17.9	31.0	3.0	9.0
3	CP-376	19.9	63.5	1.5	7.0
4	Mylone	20.6	63.5	2.0	5.0
5	Control	19.9	56.0	3.5	5.5
6	Urea-Formaldehyde(*b*)	22.6	73.0	0.0	9.0

(*a*) Average of three measurements on each plant in the treatment.
(*b*) Single plot.
(*c*) Average number of diseased plants per plot of 16 plants.

maldehyde appear to have been beneficial. The experimental material, C-272, was injurious under the conditions of this trial.

The 1958 experiment included four randomized plots of four treatments and single plots of three treatments (Table 1). The data were taken in the same fashion as in 1957 except that fruit weights were also obtained. Table 3 shows a correspondence in height and yield with disease control for only one treatment, chloropicrin. This material gave the best yield in 3 of the 7 pickings and was second or third in the others.

TABLE 3—Eggplant soil treatments 1958. Height of plants, yield and incidence of Verticillium wilt

	Treatment	Ht.(*a*)	Number fruit(*c*)	Weight fruit(*c*)	Disease averages(*c*)	
					External symptoms	Vascular browning
		in.		*lbs.*		
1	Control	14.5	37.5	38.7	7.5	8.5
2	Urea-Formaldehyde	15.0	33.7	35.1	7.7	8.5
3	Chloropicrin	15.2	45.0	46.2	2.5	3.2
4	Mylone (170 lbs.)	14.4	33.5	34.0	6.2	7.2
5	CP-376	13.9	37.2	39.7	6.0	6.7
6	EP-131(*b*)	——	20.0	23.2	8.0	11.0
7	Chloropicrin(*b*)	——	54.0	52.6	0.0	1.0
8	Mylone (340 lbs.)	——	49.0	49.9	6.0	8.0

(*a*) Average of three measurements on each plant in the treatment.
(*b*) Single plots.
(*c*) Average number of diseased plants per plot of 16 plants.

Mylone was used at a low rate in the replicated plots but the double rate single plot gives some evidence that this material was beneficial as to yield but not for *Verticillium* control. The double rate of 340 lbs. (active) per acre was a little higher than the 1957 rate and close to the rate recommended by the manufacturers. This plot was immediately adjacent to the replicated plot using the single rate and one of the control plots. There were 6 plants showing disease externally and 8 with internal browning compared to 9 and 10, respectively, in the single rate plot or 5 and 5 in the neighboring control. The high rate plot produced 49 fruits weighing 49.9 lbs. while the contiguous low rate plot produced 33 fruits with a weight of 32.9 lbs. The comparable control had 40 fruits weighing 43.8 lbs.

Statistical analysis of the 1958 height and yield data was performed. The field variability was excessive and none of the materials reached the 5 percent level of statistical significance. There was more disease in 1958 than in 1957, as shown by the numbers of plants displaying symptoms and also to some extent by the poorer yields. The weather also was generally more unfavorable for the plants which thrive in warm soils. The larger number of deaths from acute wilt in 1957 (9 of 176 plants) as compared to 1958 (0 of 320) is considered due to the stresses placed on diseased plants by heat and drought in the last part of the season. In 1958, even though more disease was present and conditions generally conducive to disease development, the August rainfall was frequent enough to save plants that would normally wilt and die. Artificially infested soil in a nearby breeding plot also gave a low incidence of acute wilt together with a high rating for vascular browning.[3] It is probable that under severe disease conditions, such as are encountered in certain commercial fields and in other seasons, that the chloropicrin would have given significant control and increased yield.

[3]Personal communication from J. L. Lockwood, Dept. Botany and Plant Pathology, Mich. State University.

FUNGICIDAL SPRAY TRIALS ON TOMATOES, 1957-58

By M. C. STRONG[1]

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THE AREA DEVOTED TO TOMATO production in Michigan has increased from 14,080 acres (49-56 average) to 16,000 acres in the past two years and the tonnage has increased from 93,900 to 130,100 tons. The total value of the crop has increased correspondingly from $5,529,000 to $6,421,000.[2] These figures include tomatoes produced commercially for fresh market and processing. In addition nearly every home gardener grows a few tomato plants.

This increase in tomato production is a result of better cultural practices, better varieties and better disease control. But we are still faced with the same disease problems as in the past. Many new chemicals for disease control are developed every year, however, and some of these may be particularly adapted to tomato.

This paper reports tests made in 1957 and 1958 to evaluate the performance of some new and old fungicides for the control of anthracnose (the ripe fruit spot) and the three blight diseases (early blight, late blight and Septoria blight) common in Michigan. The methods of culture employed and the method of obtaining data have been described in a previous report.[3]

1957 Test

Southern grown plants of the Rutgers variety were set in the field on June 2 using starter solution. Six spray applications were made between July 17 and September 14. Methoxychlor was added to the first two applications for insect control. Plots untreated with fungicide received two applications of this insecticide only.

[1]The author wishes to thank the agricultural chemical companies that furnished materials and financial aid for these tests.

[2]U.S. D. of A. Agricultural Statistics: 1958.

[3]Strong, M. C. (1950) Comparison of fungicidal sprays for the control of tomato blights. Mich. Agr. Expt. Sta. Quart. Bul. 32:338-347.

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Heavy rainfall (7.55 inches) during the first two weeks of July adversely affected plants in several low spots. These plants remained stunted all season and produced poor yields. The heavy rainfall delayed the application of the first spray by several days with the result that early blight became prevalent by that time, and good control was difficult to attain. Anthracnose and Septoria blight were present from the latter part of August to the end of the season.

The plots were inoculated with late blight on August 14 and this disease built up slowly. By the first week in September late blight was apparent and by the middle of September was severe in untreated control plots, and in some treated plots.

Late planting and a cool season delayed the harvest which was cut short by killing frost on September 20. Consequently yields were low.

DISCUSSION OF RESULTS

The yield shown in Table 1 is total marketable yield and does not include culls many of which were due to cracking and soil rot. Statistical analysis of these data showed that there were no significant differences in yield because the variation among the four replicates was frequently as great as that between treatments.

Agrimycin 500, a new antibiotic combination of streptomycin, oxytetracycline and water insoluble neutral copper, provided excellent control of late blight and when combined with ziram (zinc dimethyl dithiocarbamate) for anthracnose control, the resulting yield was comparatively high, 9.1 tons. Applications of tribasic copper sulfate plus zineb (zinc ethylene bis dithiocarbamate) provided somewhat better blight control than applications of tribasic copper sulfate alone. However, the combination of tribasic copper sulfate plus maneb (manganous ethylenebis dithiocarbamate) did not provide better control than maneb alone.

Dyrene, which had shown much promise in the 1956 trials[4] when no late blight was present, failed to control late blight infection, particularly on the fruit. Tennam, a formulation of manganous dithiocarbamate, also failed to control late blight.

The addition of Omadine (pyridinethione) disulfide to the zinc salt of Omadine considerably improved control of the latter fungicide but neither application gave satisfactory control of late blight. Phal-

[4]Strong, M. C. (1957) New fungicides and fungicide combinations for tomatoes. Mich. Agr. Expt. Sta. Quart. Bul. 39:563-569.

TABLE 1—Summary of 1957 tomato fungicidal spray trials

Treatment	Formulations	Total marketable yield Tons per A.	Percentage defoliation Sept. 26
Phaltan(*a*)	4 lb.—100 gal.	9.6	32
Tribasic $CuSO_4$(*b*)+Zineb	2 lb.+1 lb.—100 gal.	9.3	30
Agrimycin 500 (35% Cu)(*c*)+Ziram	3 lb.+1 lb. 100 gal.	9.1	30
Tennam(*b*)	3 lb.—100 gal.	9.1	35
Tribasic $CuSO_4$	4 lb.—100 gal.	8.9	40
Maneb+Tribasic $CuSO_4$	1 lb.+2 lb.—100 gal.	8.8	25
Tennam+Copozink(*b*)	1½ lb.+2 lb.—100 gal.	8.8	29
Maneb	2 lb.—100 gal.	8.7	27
Tennam+tribasic $CuSO_4$	1½ lb.+2 lb.—100 gal.	8.5	33
Dyrene(*d*)	2 lb.—100 gal.	8.2	32
Antribam(*e*)(20%)+$CuSO_4$ (25% Cu)	2 qts.+3 lb.—100 gal.	8.2	37
Omadine Zn 40%+Omadine disulfide 10%(*f*)	1 lb.—100 gal.	8.1	47
Agrimycin 500 (35% Cu)	3 lb.—100 gal.	7.7	45
Captan(*a*)	2 lb.—100 gal.	7.3	47
Agrimycin 500(*c*) (42% Cu)	5 lb.—100 gal.	7.0	52
Omadine(*f*) Zn 50%	1 lb.—100 gal.	5.8	57
Control	No Treatment	5.4	89
L.S.D.		N.S.	8

(*a*) Product of California Spray Chem. Corp.
(*b*) Product of Tennessee Corp.
(*c*) Product of Chas. Pfizer Co.
(*d*) Product of Chemagro Corp.
(*e*) Product of Nash Chem. Co.
(*f*) Product of Olin Mathieson Chem. Co.

tan, an analogue of Captan, appeared to be a much better fungicide for tomatoes than Captan and resulted in the highest yield, 9.6 tons.

The copper salt of Amtribam (diammonium ethylene bis trithiocarbamate) provided poor control of late blight particularly on the fruit.

1958 Test

Southern grown plants of the variety Campbell 135 were used in 1958. The spacing of plants was increased from 3 feet to 4 feet in the row and between the paired rows to allow the use of the tractor for cultivation to a later date. The interval between the twin rows was 6 feet as before.

Plants were set May 17 using starter solution. Very dry condition of the soil necessitated irrigation as soon as planting was completed.

Spray applications were made on July 15 and 28, August 7, 19

and 29, and September 12. Methoxychlor was added to the first two spray applications for hornworm control. Plots untreated with fungicide were sprayed with Methoxychlor only on July 15 and 28.

The plants grew well in spite of a rather dry, cool season. Early blight appeared by the middle of July and Septoria blight became prevalent late in August. Anthracnose was first observed on August 22 and was present the remainder of the season.

All plots were inoculated with late blight on August 11 and again on September 7, accompanied on each occasion by irrigation at night. The infection built up slowly. Late blight was first observed on September 10 and by September 20 was severe on the check plots and on some treated plots.

Picking began on August 9 and continued until killing frost. Other picking dates were August 14, 18, 22 and 27, September 2, 5, 10, 15, 19 and 24, and October 2. Due in part to the high productivity of Campbell's 135 and the wider spacing of plants, yields were very good. The yield shown in Table 2 is total marketable yield and does not include culls.

DISCUSSION OF RESULTS

Yields from all treated plots were significantly more than those of the untreated control plots which produced 11.7 tons per acre. Even the poorest treatment at 13.2 tons was significantly better in yield than no treatment. The highest yield was 24.1 tons per acre, or more than twice as great as that of the untreated controls.

Niacide Z[5] plus COCS[6] treated plots and Niacide M plus COCS treated plots yielded significantly more than the Niacide A plus COCS treated plots.

Niacide Z plus COCS treated plots did not yield significantly better than those treated with the Niagara combination single-package spray. However, Niacide M plus COCS treated plots yielded significantly more than plots treated with the single-package combination spray.

Dyrene, used at 3 lb. to 100 gallons, ranked in yield with zineb 1 plus COCS, Niacide Z or M plus COCS and Agrimycin 500 + ziram.

[5]Niacide is a fungicide complex of organic chemicals: Niacide Z contains 59.8 percent ziram (zinc dimethyldithiocarbamate) and 5.2 percent zinc benzothiazolmercaptide.

Niacide M contains 48 percent manganous dimethyldithiocarbamate, 12.4 percent thiram (tetramethylthiuramdisulfide), 2.4 percent manganous benzothiazylmercaptide and 2.2 percent 2-2′-dithiobisbenzothiazole.

Niacide A contains 35 percent ferbam (ferric dimethyldithiocarbamate), 24 percent manganous dimethyldithiocarbamate, 6.2 percent thiram (tetramethylthiuram disulfide), 1.2 percent manganous benzothiazylmercaptide and 1.1 percent 2-2′-dithiobisbenzothiazole.

The single-package Niagara combination contained equal parts of Niacide Z plus COCS.

[6]COCS is copper oxychloride sulfate (55 percent metallic copper).

TABLE 2—Summary of 1958 tomato fungicidal spray trials

Treatment	Formulations	Total marketable yield Tons per A.	Percentage defoliation Sept. 20
Niacide M(*a*)+COCS(*a*)	1.5 lb.+1.5 lb.—100 gal.	24.1	14.2
Dyrene(*b*)	3 lb.—100 gal.	23.9	23.1
Niacide Z(*a*)+COCS	1.5 lb.+1.5 lb.—100 gal.	23.5	15.3
Zineb 1+COCS	1 lb.+1½ lb.—100 gal.	23.3	15.2
Agrimycin 500 (35% Cu) (*c*)+Ziram	3 lb.+1 lb.—100 gal.	22.5	14.4
Niagara Combination(*a*)	3 lb.—100 gal.	22.3	19.1
Niacide A(*a*)+COCS	1.5 lb.+1.5 lb.—100 gal.	21.6	20.1
Phaltan 50 W+sticker(*d*)	3 lb.+1 pt. per acre	21.2	30.3
Amobam(*e*)+Ca hypochlorite	1 qt.+1 lb.—100 gal.	20.4	32.2
Captan 80 W+sticker(*d*)	2 lb.+1 pt. per acre	20.2	30.5
Zineb 2	2 lb.—100 gal.	19.2	29.1
Captan 50 W+sticker	3 lb.+1 pt. per acre	19.0	32.5
Phaltan 50 W(*d*)	3 lb. per acre	18.5	41.6
Captan 80 W(*d*)	2 lb. per acre	18.3	40.8
Zineb 1+Tegal(*f*)	1 lb.+.1%—100 gal.	17.4	30.2
Amsul(*g*)+Mn SO_4	2 qts.+2 lb.—100 gal.	16.7	62.7
Phytoactin(*f*) 200	200 p.p.m.	15.6	35.2
Zineb ½+Tegal	.5 lb.+.1%—100 gal.	15.1	51.3
Phytoactin 400	400 p.p.m.	13.2	40.8
Control	No Treatment	11.7	92.8
L.S.D. (1%)		1.5	7.7

(*a*) Product of Niagara Chem. Div. of Food Machinery and Chem. Corp.
(*b*) Product of Chemagro Corp.
(*c*) Product of Chas. Pfizer Co.
(*d*) Product of California Spray Chem. Corp.
(*e*) Product of Roberts Chemical Co.
(*f*) Product of Tennessee Corp.
(*g*) Product of Nash Chemical Co.

In 1957 a lower rate of Dyrene, 2 lb. to 100 gallons, failed to control late blight infection on fruit.

Plots treated with zineb at 1 lb. plus Tegal, a synergist, yielded significantly more than plots treated with zineb at ½ lb. plus Tegal. The latter provided very poor control of late blight. Plots treated with zineb at 2 lb. without Tegal produced significantly greater yields than plots treated with either of the zineb plus Tegal combinations. Plots treated with zineb at 1 lb. plus COCS produced significantly greater yields than plots treated with zineb alone or with either of the zineb plus Tegal combinations.

Plots sprayed with Phaltan 50 percent plus sticker yielded significantly more than plots sprayed with Phaltan 50 percent without sticker. Phaltan is an analogue of Captan. Plots sprayed with Phal-

tan 50 percent plus sticker yielded significantly more than plots treated with Captan 50 percent plus sticker. Plots sprayed with Captan 80 percent plus sticker yielded significantly better than plots treated with Captan 80 percent without sticker.

Amobam (42 percent diammonium ethylene bis dithiocarbamate) plus Ca hypochlorite produces ethylene thiuram sulfide. In the first year of test here, this material was approximately equivalent in yield to Phaltan or Captan plus sticker, zineb at 2 lb. and Niacide A plus COCS.

Agrimycin 500 (35 percent metallic copper and streptomycin 100 ppm) plus ziram was a satisfactory combination with a 22.5 ton yield, and ranked with zineb 1 lb. plus COCS and Niacide Z plus COCS. Agrimycin 500 plus ziram provides excellent control of late blight.

Amsul (20 percent ammonium bis ethylene disulfide) plus $MnSO_4$ under test for the first time here was not very satisfactory. The yield was 16.7 tons and the material failed to control late blight and *Septoria* blight.

Phytoactin, an antifungal antibiotic, at 200 p.p.m. was significantly superior in yield with 15.6 tons to the same material at 400 p.p.m. with 13.2 tons. However, Phytoactin at 200 p.p.m. failed to control late blight infection on the fruit.

CONCLUSIONS AND RECOMMENDATIONS

A good fungicidal spray program will greatly increase total marketable yield of tomatoes. Thorough coverage and proper timing are necessary for best results. A tank-mix combination of a fixed (water insoluble) copper plus ziram or zineb each at one half the manufacturer's recommended rate of application will provide good control of anthracnose and the three blight diseases. Niacide Z or M plus COCS and tribasic copper sulfate plus Parzate or Dithane Z-78 are examples of such combinations.

Dyrene at 3 lbs. per 100 gallons or maneb are also recommended fungicides.

Phaltan has given much promise in two seasons' tests and may be recommended after further testing. Agrimycin 500 plus ziram also has given very satisfactory results in the 1957 and 1958 trials, but as of this date may not be used on tomatoes after fruit set because it has not been accepted by the U. S. Food and Drug Administration for such use.

THE EARNING CAPACITY OF INPUTS USED IN MICHIGAN ELEVATORS[1]

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THIS STUDY WAS UNDERTAKEN to obtain insight into the over-all operating efficiency of local elevators in Michigan. The analysis is developed with the assumption that the elevator business uses resources to produce a marketing service. The charge for this service is gross margin.

Using gross margin as a basis for measuring what the elevator produces, the following general conclusions emerge: (1) labor has a relatively low earning capacity compared with its cost, (2) the return to liquid capital is not greatly in excess of its probable cost, (3) the returns to the fixed plant appear to be generally adequate, and (4) dollars spent on power, supplies, and other current operating outlays yield a high return.

The formal analysis and measurement of these relationships as developed in this study are presented to increase insight into the magnitude of the adjustment problem facing elevator managers and to provide a better basis for evaluating specific changes which might be made to improve operations.

THE NATURE OF THE PROBLEM

The elevator plays an important role in agriculture. It serves as an assembling plant for the movement of grain through the marketing system and as a distributor of numerous supplies used in farm production. The dynamic nature of present day agriculture is such that in order to properly fulfill these roles, adjustment to new conditions is constantly necessary. These adjustments must be made in the face of competitive pressures from both local and large businesses which

[1]This report is based on an M.S. thesis by Arthur J. Pursel (1957), "The use of functional analysis in evaluating the operations of Michigan elevator—farm supply business", Dept. of Agricultural Economics, Michigan State University.

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provide some or all of the services normally provided by the elevator. Hence the problem of organizing business operations so that the investment in plant facilities and expenditures on labor and other operating costs yield an adequate net income is a major problem facing managers.

Many of the elevators now active in Michigan have been operating 30 to 50 years or more. Some have been modernized and are up-to-date in the sense of being well mechanized with a corresponding reduction in use of labor. Others, where plant facilities are old, require larger amounts of labor to overcome the lack of mechanization. At any particular point of time each manager must operate with the plant facilities which are available. The only feasible short-run adjustments that can be made are those which change the intensity with which facilities are used. In the long run, however, it is possible to adjust the kind and type of plant facilities as well as to improve the capabilities of labor and management.

When decisions to adjust operations are made, it is necessary to have some insight into the relative earning capacity of expenditures on different production inputs. Questions such as, will an additional man pay for himself?, or conversely, will letting a man go reduce revenue more than the saving in wages?, or, will investment in another truck, a grain dryer, or some other item pay for itself? are extremely relevant to determining the kind of operating adjustments managers should make. Answering these questions is basic to estimating potential improvement in earning capacity.

OBJECTIVES OF THE STUDY

An attempt has been made to provide over-all guides to help managers decide what general course can be followed to improve earnings. This was done by developing estimates of the income producing capacity of several categories of inputs used in Michigan elevators and by estimating the effects of varying the combinations in which they are used. In order to obtain these estimates, information was obtained from the financial records and by direct interview of 34 typical elevators throughout Michigan. These elevators are typical in that the products handled and the services performed are essentially alike. Businesses which handled large amounts of lumber, building materials, or other items which are not commonly handled by most elevators were eliminated from the sample.

HOW THE ESTIMATES WERE MADE

An estimate of the kind developed here requires specifying (1) what represents output and how it should be measured and (2) what input categories should be used, and how the quantity used should be measured. These problems are handled as follows:

Income: Gross margin is used as a measure of output to the elevator. Elevators provide a service and gross margin provides the truest measure of the value of the service. This also is the amount of money available to cover the cost of maintaining the plant, to pay labor and cover all other costs. The fact that some elevators operate in situations where unit margins are larger than others has been accounted for by eliminating these differences. An average unit margin was computed for each important commodity and this was used to compute an index of the value of services provided by each elevator. The average gross margins used are shown in Table 1.[2]

The input categories which were used and the method of measurement were as follows:

1. **Labor:** Includes all plant labor, truck drivers, sales personnel, and other persons engaged in activities which directly further the operations of the business. Persons employed as bookkeepers and other office personnel were not included. Detailed records on the activities of each individual were obtained and

[2]Though wide differences were found in the unit gross margins on individual commodities, e.g. a range of 3 to 12 cents per bushel for handling wheat, the variation in percent of over-all gross margin was much narrower. Operators who handle one commodity for a low margin tend to make it up elsewhere.

TABLE 1—Average unit gross margins charged by 34 elevators

Commodity	Charge
Beans/bu	$ .43
Corn/bu	.07
Wheat/bu	.06
Oats/bu	.05
Barley/bu	.11
Rye/bu	.10
Soybeans/bu	.12
Feed/ton	12.61
Fertilizer/ton	5.59
Coal/ton	3.91
Seed/percent	18.60
Light fuels/percent	20.30
Other farm supplies/percent	15.60

in cases where time was split between office and operational duties, time spent on operational duties is included. The unit of measure used is man-months, which is one man's time for one month or in the case of a full-time employee the amount of labor provided in a year's time is 12 man-months. This kind of measure rather than number of employees was used to facilitate allocating the time of individuals to office and operational duties and to provide a more precise basis for handling part-time employees.

2. **Operating expenses:** Expenditures which tend to vary with the volume of business. Included are such things as power, hired trucking, and other items used directly in the operations of the business. Overhead cash expenditures such as taxes, auditors' fees, etc., which must be made but do not contribute directly to the production of income, were excluded.

3. **Inventories and accounts receivable:** Measures the level of investment required in current assets to carry on the business. The value used is the average monthly accounts receivable and average monthly value of inventories throughout one year's time.

4. **Machinery and equipment:** The values used are engineering estimates of the replacement value of machinery and equipment included in each elevator during the fiscal year ending in 1955.

The following general points should be noted about the above input categories. They are grouped into two investment or asset categories and two categories which represent current costs shown in the operating statement. Only those categories which contribute directly to the day-to-day operations of the business are included. This means that the earnings attributed to these items must be high enough to pay their costs and also to cover overhead costs and support the additional investment (in the latter case, primarily buildings) needed along with these items. The quantities of inputs used in the typical case for the 34 elevators is shown in Table 2.

For the typical elevator the annual index value of services performed (i.e. gross margin) is $83,674.

Once the facts shown in Table 2 are known the questions which arise are (1) to what extent is each of these inputs individually paying its cost and contributing to payment of overhead costs, and (2) how

TABLE 2—Quantities of inputs in typical elevator

Item	Amount
Labor used in a year	101.3 man-months
Average monthly inventory and accounts receivable investment	$76,194
Yearly cash outlay on direct operating expenses	$13,305
Replacement value of machinery and equipment	$58,697

will income change if the level of use of different inputs individually or in combination is changed? The analysis which follows will provide insight into these questions.

RESULTS AND IMPLICATIONS OF THE ANALYSIS

The return to labor is barely sufficient to cover its cost. If an elevator operated as successfully as the average of the 34, the reduction of the labor force by one man's time for one month would decrease earnings by $320. Costs on the other hand would be reduced by $311.50 (the average monthly wage paid).

In the future, quality of personnel will probably have to increase in order to handle the increasingly complex problems that farmers will have with feeding rations, crop fertilization, insect and disease control and other areas of management. Wages to this caliber of employee will probably be higher than the current average. Also, the continued trend of higher wages in industry will probably put considerable upward pressure on wage rates. The possibility of labor unions in the elevator business may also increase wage rates. All of these factors point to the need for operating adjustment which will assure that the returns to labor will be great enough to cover higher unit labor costs.

The returns to inventory and accounts receivable is 17.9 cents for the last dollar invested. This means that the interest return on this investment is 17.9 percent annually in the typical elevator and it can be evaluated only in the light of the costs involved. The cost of providing credit includes an interest charge on the money used, bad debt losses which might occur, plus accounting and collection costs. The costs to be considered in maintaining an inventory are interest on investment, depreciation, taxes and normal loss through damage and other means. Though no applicable figures appear to

be available on the cost of maintaining a liquid capital investment, it would not appear that 17.9 percent represents a high return rate. Costs probably closely approach this figure.

The annual return to machinery and equipment is 26.8 cents for each $1.00 invested. Though this return may appear high it must be kept in mind that the costs involved in maintaining plant investment include depreciation, maintenance and repair, interest on investment, insurance and taxes. When viewed in this way, 26.8 percent does not appear excessive but probably does provide an adequate return.[3]

The return received for each dollar spent on direct operating expenses amounts to $1.70. This is high and can be interpreted to mean that the best way for elevator operators to increase earnings is to increase the flow of materials through the elevator without increasing investment in plant or current assets and without increasing the size of the labor force. Grinding more feed, handling more grain, and most other forms of service which the elevator provides require additional expenditures on power, truck operation expenses, etc. The direct relationship between expenditures and the volume of business handled along with the high returns to these expenditures indicates the extent to which inadequate volume for the size of plant maintained is a basic malady of the elevators included in this sample. To increase volume with a given total investment and labor force, inventory turnover must increase, plants must be in actual operation more hours and sales must go up.

It must be realized that elevators and farm supply firms are merchandizing firms as well as processing firms. The adjustment to a higher level of outlay on operating expenses is essentially a production type adjustment which can be made only by expanding volume through buying and selling activities.

The average plant in the sample utilized 9.32 percent of its grain handling capacity and 48.95 percent of its feed processing capacity.[4] While these are only rough estimates, they do give an indication of the amount of excess plant capacity that is available to expand volume.

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[3]Technical Footnote: A Cobb-Douglas type production function was fitted and the following results were obtained: Gross Margin = 1.33910 (Labor)$^{.38798}$ (Inventory and accounts receivable)$^{.16343}$ (Direct operating expense)$^{.26972}$ (Investment in machinery and equipment)$^{.18770}$ where $\sigma b_1 = .12338$, $\sigma b_2 = .08317$, $\sigma b_3 = .09006$, $\sigma b_4 = .09045$, $\bar{s} = .04888$ and $R^2 = .87.2$. Estimates of the marginal value products of the input categories were computed from the function.

[4]Percent utilization is based on rated grain or feed handling capacity for a 305-day period at 8 hours per day. Some feed or grain business is done nearly every day of the year; however, seasonal fluctuations must be considered.

THE RESULTS OF ADJUSTMENT

If the volume of business for the average elevator were expanded to the point where annual outlay on cash operating expenses increased to $27,250 a better than two-fold increase is obtained in the utilization of plant facilities and labor. These results apply only if the products handled do not change from the average proportions included in the sample. Table 3 shows the effects on the last unit of each input used by the "usual" elevator, as a result of adjusting the business in the above way.

TABLE 3—Returns to last of unit of each input for "usual" elevator as a result of increasing direct operating expenses from $13,305 to $27,250

Input category	Quantity of inputs	Original returns (dollars)	New returns (dollars)
(1) Labor	101.3 man-months	$320.32	$388.64
(2) Inventory and accounts receivable	$76,194	.179	.217
(3) Direct operating expenses	$27,250	1.696	1.004
(4) Investment in machinery and equipment	$58,697	.267	.324

The values under the headings "original returns" and "new returns" in this table should be interpreted as follows: If volume is increased as shown, each man will then be working hard enough and effectively enough so that the revenue loss through employment of one less man for one month will be $388.64 instead of $320.22. With a wage rate of $311.50 the loss would be substantially greater than the cost. In like manner if the business is short of liquid operating funds the loss of $1.00 will reduce revenue 21.7 cents and the loss of $1.00 to finance facilities will reduce revenue 32.4 cents. Both the labor force and investments are paying off better as volume is adjusted upward.

This in itself is probably not a startling conclusion to those acquainted with the operation of elevators. However, the estimation of the nature of the change in earnings to individual input categories should be of some value in business planning. The question which is not answered here is how this adjustment is to be brought about with the least cost. This requires a consideration not only of what particular services or commodities have the greatest market potential

but also of how the market is most easily penetrated. For some commodities advertising and promotion may be the answer, for others personalized salesmanship, and in still others providing a financing or management service along with the commodity may represent the most effective way of expanding output. In any event both the total net additional revenue and the additional cost must be weighed carefully.

The estimated total gross margin increased from $83,674 to $101,517 as a result of increasing volume enough to require $27,250 of direct operating expenses while holding the level of investment and labor employment at the average level.

It would seem that the next question to be answered is the effect on net operating profit as a result of making this adjustment. Profit is a residual value obtained after costs are deducted from gross revenue. The elevator operator is concerned about the absolute magnitude of net operating profit and the rate of return it represents on investment. Total operating expenses including depreciation for the "usual" elevator is $76,823. When this is subtracted from a gross margin of $83,674, a net profit of $6,851 is obtained. The average net fixed assets of the 34 elevators studied was $69,502. Net operating margin as a percentage of net fixed assets is 9.86 percent.

If the purposed adjustment could be made, net profit would increase from $6,851 to $10,749. The rate of return on net fixed assets would increase from 9.86 to 15.46 percent, or an increase of 56.95 percent.

LONG-RUN ADJUSTMENT

Another type of reorganization which seems feasible is the adjusting of both operating expenses and plant investment simultaneously. The high rate of return on direct operating expenses and investment in machinery and equipment indicates that increases in the amount of these two items could enhance the gross margin of the firms studied. This is to say that if earnings are increased by operating closer to capacity they should be increased even more by both increasing the percent of capacity and increasing plant size. The amounts used of each should be in a proportion which permits the lowest possible cost for attaining a certain level of gross margin. Several trial levels of different amounts of direct operating expenses and investment in machinery and equipment were made while labor, inventory and accounts receivable were held at the "usual" amounts. The optimum

amount of direct operating expenses to be used was found to be $31,750 combined with $110,000 invested in machinery and equipment (Table 4).[5]

It can be seen from Table 4 that the earnings of the last month of labor has increased substantially. The earnings of the last dollar of inventory and accounts receivable has also increased. The returns to the two other inputs has decreased, as would be expected when greater amounts are used.

TABLE 4—Changes in the earnings of each input for the "usual" elevator resulting from increases in direct operating expenses and investment in machinery and equipment

Input category	Quantity of inputs	Original returns (dollars)	New returns (dollars)
(1) Labor	101.3	$320.32	$455.66
(2) Inventory and accounts receivable	$76,194	.179	.255
(3) Direct operating expenses	$31,759	1.696	1.011
(4) Investment in machinery and equipment	$110,000	.267	.203

EFFECTS ON PROFIT

Estimated total investment priced at replacement value for the expanded plant is $318,943 which would make the average investment over a period of years equal to approximately one-half of this, or $159,471.50 (Table 5).

Net operating profit is only modestly greater with long-run adjustment as with the short-run adjustment. This is due to the increased total depreciation charge on the higher investment in facilities. However, an additional idea must be brought into the analysis at this point. In a longer-run period the amount of cash made available from business operations depends on both the level of net earnings, as recorded in the operating statement, and on the amount of depreciation charged. The combined value of these represent the amount of liquid capital which becomes available to the business in any given time period. If the value of facilities is large the depreciation charge (theoretically the amount set aside to replace facilities) will be large. Hence it becomes necessary to look at both earnings and depreciation in evaluating longer-run business prospects.

[5]This conclusion is not precisely true because the solution noted in footnote 2 indicates increasing returns to scale. The approximation is, however, close enough that the error is insignificant.

TABLE 5—Accumulation of liquid capital related to average investment in facilities with three operating situations

	Usual elevator	Short-run adjustment	Long-run adjustment
Net profit	$ 4,036	$ 7,934	$ 9,824
Depreciation charged(*a*)	10,373	10,373	21,492
Annual accumulation of liquid capital	$ 14,409	$ 18,307	$ 31,316
Total replacement value	153,943	153,943	318,943
Average investment over a period of years	76,971	76,971	159,471
Accumulation rate on investment over a period of years	18.72	23.78	19.64

(*a*) Rates of depreciation: 5.73 percent on buildings, machinery and equipment, and 20.16 percent on trucking equipment. These rates are computed on the basis of 24 elevators. Inadequacies in balance sheet data made it impossible to compute an average rate based on all of the 34 elevators studied.

The importance of the idea of liquid capital accumulation lies in the fact that the rate of accumulation relative to total investment determines the firm's ability to maintain and modernize its physical plant and provide a return on investment.

Table 5 shows the absolute amount and the rate of liquid capital accumulation when facilities are priced at replacement values in all situations.

It is seen from Table 5 that the greatest absolute amount of accumulation occurs in the long-run adjustment situation. However, the rate of accumulation is highest in the short-run adjustment situation. This indicates that for the elevator defined as "usual" in this analysis, efforts should first be made to increase the utilization of existing facilities before consideration is given to plant expansion.

TABLE 6—Values used in estimating earning capacity of inputs (The time period for income and expense items is one year)

Elevator number	Man-months of productive labor	Average monthly accounts receivable and inventory (dollars)	Direct operating expenses (dollars)	Replacement value of machinery and equipment (dollars)	Index of marketing services (dollars)
1	117	93,415	22,739	48,382	87,571
2	40	26,280	4,722	33,737	34,652
3	192	122,929	7,400	43,078	72,724
4	83	96,031	17,383	49,346	78,767
5	66	55,986	11,216	41,851	52,554
6	90	71,512	10,190	61,302	63,580
7	42	26,392	10,468	23,657	30,371
8	252	153,906	21,814	67,596	130,984
9	132	98,790	14,439	66,834	88,186
10	108	95,859	19,769	130,655	103,611
11	252	131,887	27,140	91,852	191,291
12	137	92,471	14,812	76,785	107,098
13	51	35,504	8,191	31,945	37,796
14	100	77,459	10,835	67,172	62,476
15	52	37,436	12,479	18,445	66,577
16	52	38,658	10,581	25,000	43,079
17	46	20,399	5,909	40,658	39,508
18	164	101,462	17,811	41,840	151,947
19	120	78,889	22,314	47,500	81,198
20	336	180,095	44,428	97,017	260,457
21	106	59,683	19,389	100,482	118,705
22	166	80,323	21,552	110,100	116,998
23	180	65,099	16,454	86,997	159,929
24	50	33,850	5,686	72,821	57,485
25	82	206,697	7,038	65,524	84,191
26	76	28,447	8,934	53,101	44,240
27	54	45,097	7,394	48,862	54,626
28	77	49,545	14,519	58,227	77,964
29	114	106,236	8,553	61,562	87,371
30	148	214,027	33,383	77,797	168,804
31	84	65,701	8,785	34,553	83,749
32	240	188,415	44,058	165,738	218,755
33	162	277,114	18,402	99,475	147,427
34	72	143,454	6,067	105,537	77,790

A STUDY OF HYPOXYLON CANKER ON ASPEN

By MAURICE W. DAY[1] and FORREST C. STRONG[2]

HYPOXYLON CANKER *Hypoxylon pruinatum* (Klotsche) cke. on aspen *Populus tremuloides* Michx. has been causing increasing losses in recent years. Foresters and pathologists are particularly interested in learning more about the disease and its effects on stands of aspen. The authors were of the opinion that a study of individual trees and cankers together with environmental observations would yield useful information on the progress of the disease in infected trees.

The study, begun in 1948 at the Dunbar Forest Experiment Station near Sault Ste. Marie, Michigan, has followed the progress of the disease on the trees contained in 15 permanent sample plots which had been established in connection with a study of thinning practices for aspen.[3]

Ten plots were located in a 29-year-old stand growing on a good site (85 foot height at 50 years); three plots were located in a 21-year old stand on a medium site (60 feet at 50 years); and two plots were in an 11-year-old stand on a good site. After five years the 3 plots in the 21-year-old stand were lost by flooding from a beaver dam. On the other plots yearly examinations were made for the 8-year period from 1948 to 1956, inclusive.

Some of the plots had been subjected to thinning so that stand density varied considerably. The groups of sample trees as a whole, however, are quite representative of young aspen stands in this region. The stand also contained a mixture of balsam poplar, *Populus tacamahaca* Mill. which did not enter into the problem since no cankers were found on this species. Big tooth aspen, *Populus grandidentata* Michx.

[1]Department of Forestry.
[2]Department of Botany and Plant Pathology.
[3]Day, M. W. (1958) Thinning aspen in upper Michigan. Mich. Ag. Expt. Sta. Quart. Bul. 41:311-320.

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was not present. Some balsam fir, *Abies balsamea* (L.) Mill. and white spruce *Picea glauca* (Moench) Voss. were scattered through the stand.

During the period covered by this study, the area was subjected to a severe outbreak of the forest tent caterpillar, *Malacosoma disstria* Hubn. which resulted in complete defoliation of the aspen in 1951 and partial defoliation in 1950 and 1952. These defoliations resulted in a reduction of vigor of all trees and probably was a factor in the death of many weaker ones.

At the start of the study, all of the trees in each plot were carefully examined for cankers and recorded. Each canker was recorded by tree number, height from the ground, length and width of canker, aspect and a few descriptive details. At each re-examination, the cankers were remeasured, condition of trees noted and another search was made for new cankers. It was difficult to make accurate determinations on cankers in the upper part of the taller trees, although field glasses were used to assist in making these determinations. Only those trees found after repeated observations to be definitely infected are included in these data. All trees that died were examined to determine if death was due to hypoxylon canker or other causes.

In 1948, 19 trees were found dead from the effects of *Hypoxylon* canker and the living trees with cankers numbered 70. During the course of the study, 35 more trees became infected making a total of 105 diseased trees. Of this number, 72 trees (68.5 percent) died from the effects of the disease and 33 were still alive at the end of the 8-year period. Since the 15 plots contained a total of 1,460 aspen trees, it appears that 7.2 percent were infected with canker and 5 percent were killed by canker during the study. Table 1 shows the total number of aspen trees, the number of trees infected, the annual mortality and the number of newly infected trees by individual plots.

A check of all the sample tree records showed that the average length of time before the trees died from canker was 3 years. However, it varied from 1 to 5 years and since the cankers were usually of some size before being discovered, it is evident that the length of time necessary for a canker to girdle a tree is somewhat more than the figure mentioned above.

A diligent search was conducted for very young cankers but very few were found. The very small cankers are difficult to identify and it is also likely that the cankers develop quite rapidly at this stage. An attempt was made to measure the growth of several cankers by

TABLE 1—Data on infection, mortality and survival of aspen trees, affected with Hypoxylon canker

Plot(*a*) No.	Number aspen trees	1948		1949		1950		1951		1952		1953		1954		1955		1956		Totals		
		Dead	Alive	Died	New cankers	Died	New cankers	Died	New cankers	Died	New cankers	Died	New cankers	Died	New cankers	Died	New cankers	Died	New cankers	Dead	New cankers	Alive
1	64	3	5	0	0	0	1	0	1	2	1	3	0	0	0	1	0	0	0	6	3	2
2	40	0	7	2	0	3	0	0	0	2	0	0	0	0	0	0	0	0	0	5	0	2
3	75	1	5	1	0	0	0	1	0	1	0	0	0	0	0	0	0	0	0	3	0	2
4	48	0	1	1	0	0	1	2	2	0	0	0	0	0	0	0	1	0	0	3	4	2
5	100	4	4	0	0	1	1	0	1	0	0	5	2	0	0	0	0	0	0	6	4	2
6	55	1	8	1	0	2	0	2	0	0	1	0	1	0	0	0	0	1	1	6	3	5
7	51	2	5	0	0	1	0	1	0	1	0	2	1	0	0	0	1	0	0	5	2	2
8	51	1	4	1	0	0	0	2	0	0	0	0	1	0	1	1	1	0	0	4	3	3
9	33	0	5	0	0	0	2	2	0	0	0	4	0	1	0	0	0	0	0	7	2	0
10	28	1	1	1	0	0	0	0	1	0	0	1	0	0	0	0	0	0	0	2	1	0
11	136	0	8	1	1	1	1	3	1	0	0	1	1	*	*	*	*	*	*	6	4	6
12	547	6	8	3	0	1	2	2	1	0	0	4	2	*	*	*	*	*	*	10	3	1
13	102	0	4	0	1	0	0	1	0	0	0	*	*	*	*	*	*	*	*	1	1	4
14	50	0	2	0	0	0	1	0	1	0	0	1	0	2	0	0	0	0	0	3	2	1
15	80	0	3	0	0	0	0	0	0	1	0	3	3	1	0	0	0	1	0	5	3	1
Totals ..	1460	19	70	11	2	9	9	16	8	5	2	24	11	4	1	2	3	2	1	72	35	33

*Plots lost due to establishment of a beaver flowage.
(*a*) Area of plots 1 to 10, 1/4 A. each; plots 11 to 13, 1/5 A. each; plots 14 and 15, 1/10 A. each.

driving nails in at points along the boundary of the canker. At subsequent examinations the growth of the canker beyond the nails was measured.

Records of canker measurements on 18 infected trees taken in 1948, 1949 and 1950 showed that the growth increase varied from 4 to 24 inches in length and 2 to 15 inches in breadth. The average increase in size from August 1948 to August 1949 was 10.4 inches in length and 3.5 inches in width. During the succeeding year (August 1949 to 1950), the average increase in size was 11.4 inches in length and 5.9 inches in width. The average growth during the second year of the study was greater than that during the first year by 1 inch in length and 2.4 inches in breadth.

Fig. 1 shows how the average increase in canker growth on these 18 trees correlates with the temperature and rainfall records for the growing periods of 2 years. Since the non-callus forming or diffuse types of canker such as that normally produced by *Hypoxylon* grows only during the same period as the tree, the temperature and rainfall figures used in the graph were for the 3 growing months during which the trees and cankers are active.

Most of the 18 trees under consideration died from the effects of

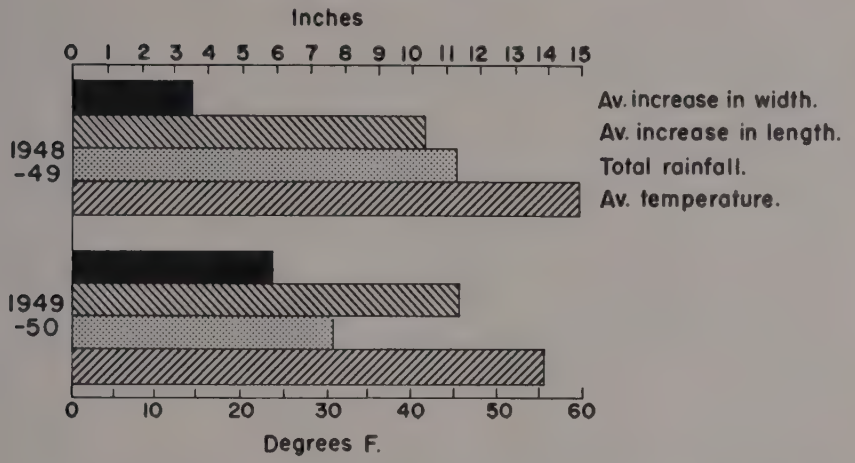

Fig. 1. Comparison of growth rate of Hypoxylon cankers with total rainfall and average temperature during May, June and July. (Climatological Data, Weather Bureau, U. S. Dept. of Commerce.)

the disease prior to the next annual examination so the comparison could not be carried further. However the 2-year comparison indicates that the cankers increased in size more in the cooler period accompanied by less rainfall.

A comparison of the *Hypoxylon* infected trees in this study reveals an interesting relationship between the average height of the canker on the bole and the d.b.h. of the tree as shown in Fig. 2. This

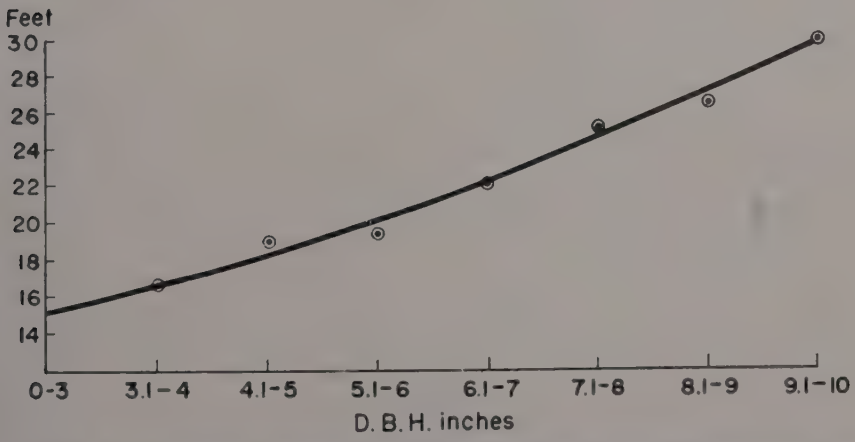

Fig. 2. Comparison between d.b.h. and height of Hypoxylon canker on the aspen bole.

agrees with the observation of Bier[4] that the older the tree, the higher the canker on the bole. Older bark near the base of large trees is seldom infected.

There were a number of cankers in the upper part of the crown and in most cases this resulted in the death of the portion above the canker. Many of these crown cankers did not cause the death of the tree and in a few years the remaining crown developed to normal size. When a remnant of the original canker remained in the crown, it did not continue to be active. It can be said, therefore, that cankers in the upper portion of the crown do not doom the tree and may in some cases permit the tree to remain in the stand until harvested.

There are some cankers that appear to be dormant and have callus growth developing around the canker area. These cankers may, however, become active and quickly kill the tree.

When the plots in the three age series were separated into groups on the basis of stand density and the incidence of canker was calculated, it was found that the incidence of disease was greater in the poorly stocked stands and less in the well stocked stands at each age level. This relationship is shown in Table 2 and Fig. 3. These findings, while contrary to most phytopathological concepts, are in accord with the observations of Anderson,[5] and may possibly indicate

[4]Bier, J. E. 1940. Studies in forest pathology. III. Hypoxylon canker of poplar. Dom. of Can. Dept. of Ag. Pub. 691 Tech. Bul. 27.
[5]Anderson, R. L. (1956). Hypoxylon canker of aspen. U.S.D.A. Forest Service, Forest Pest leaflet 6.

TABLE 2—Comparison of incidence of Hypoxylon canker in well stocked and poorly stocked stands

Age of stand	Well stocked stand					Poorly stocked stand				
	Plot No.	Total trees	No. Aspen trees	No. cankered trees	Percentage diseased	Plot No.	Total trees	No. Aspen trees	No. cankered trees	Percentage diseased
29 yr.	2	110	40	7		1	83	64	8	
	3	95	75	5		4	64	48	4	
	5	174	100	6		6	90	55	9	
	7	100	51	5		9	52	33	7	
	8	127	51	4		10	49	28	9	
	Total	606	317	27	8.5%		338	228	35	15.3%
21 yr.	12	619	547	12	2.2%	11	145	136	11	
						13	108	102	5	
							253	238	16	6.7%
11 yr.	15	165	80	3	3.7%	14	76	50	3	6.0%

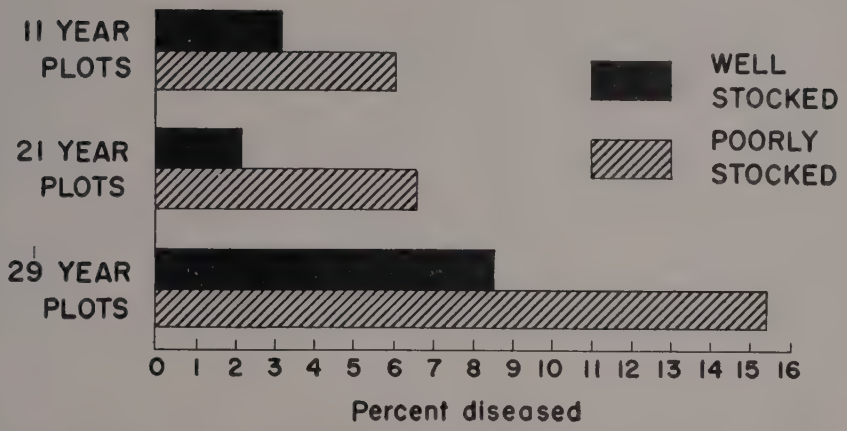

Fig. 3. Comparison of incidence of infection by Hypoxylon canker in well stocked and poorly stocked stands.

that in more dense stands the wounding or bark injury necessary for the invasion by this fungus occurs less frequently than in more open stands.

An attempt was made to correlate the number of newly infected trees and number of trees killed by canker annually with climatological data for the growing season and also with measurements of increment cores. There was an inverse correlation between number of newly infected trees and average rainfall for the years under consideration in this study, the number of newly infected trees being greater in periods of less rainfall (Fig. 4). There seemed to be no correlation between temperature and increment measurements, number of trees killed by canker or number of newly infected trees. Any relationship among these data seems to have been overshadowed by the effects of defoliation by the forest tent caterpillar. A lag of 1 year appears between the complete defoliation of 1951 and the smallest increment in 1952. The impact of this defoliation on number of trees killed by canker shows another lag of one year, the highest mortality being in 1953. The largest number of newly infected trees was also recorded for the same year.

An attempt was made to induce cankers in healthy trees in order that the development of the canker might be studied. A mass of Hypoxylon lesion bark was used as inoculum and it was pounded

into a wound made on clean smooth bark with a hammer.[6] A total of 38 such inoculations and 10 check lesions were made in August

[6]Gruenhagen, R. H. 1945. *Hypoxylon pruinatum* and its pathogenesis on poplar. Phytopath. 35: 72-89.

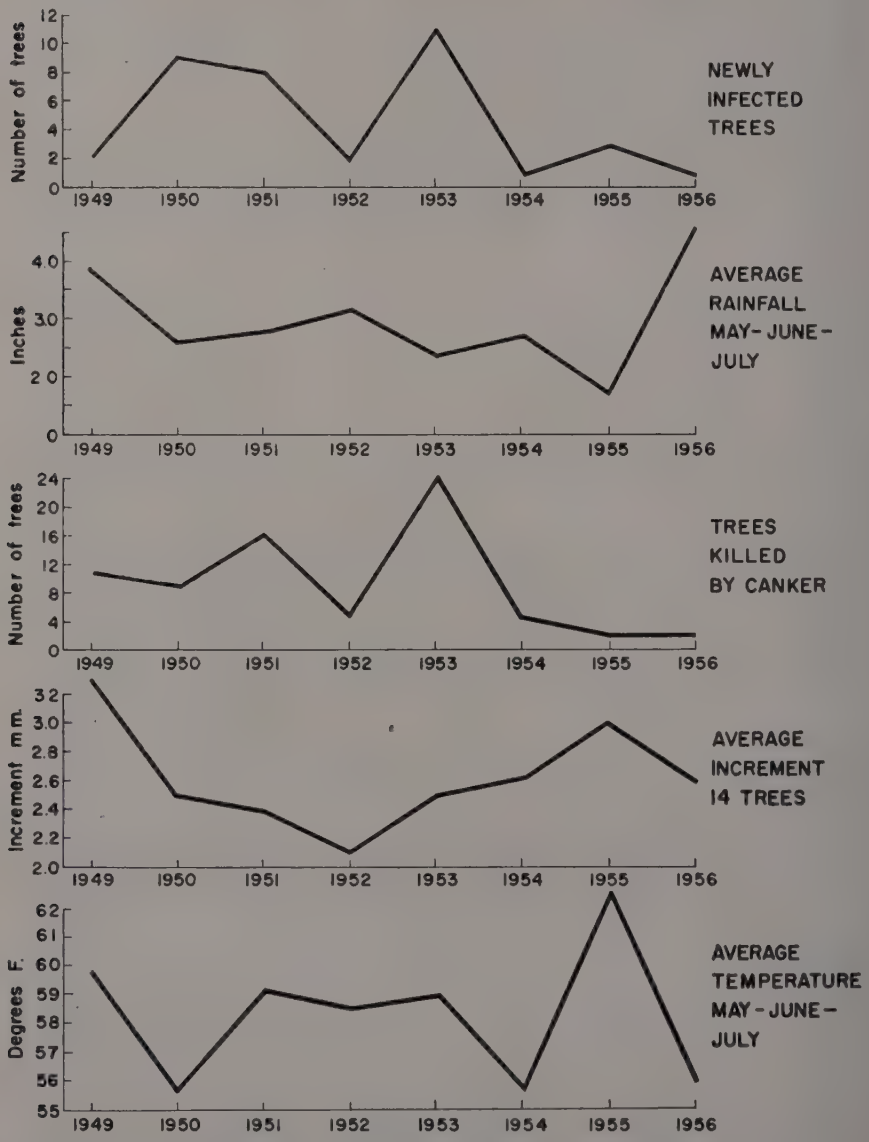

Fig. 4. Comparison between annual climatic factors, aspen growth and Hypoxylon canker development.

1952. Examination in subsequent years showed no evidence of canker infection in any of the wounds. Another series was established in September 1954 using the same treatment except for a covering of waterproof paper placed around the trunk and over the lesion. This also resulted in no evidence of infection in any of the treatments after two years.

SUMMARY

This study of Hypoxylon canker on aspen was concerned with the progress of the disease on specific sample trees which were examined at least annually over a period of 8 years.

In each age group of plots the greater incidence of canker occurred on the less dense stands. Growth rates of measured cankers varied considerably and growth rates of individual cankers varied with the season. A comparison of the seasonal variation in canker growth with weather records indicated that canker growth was greater in a cool dry season. The height of the canker on the bole was directly related to d.b.h. of the tree; the larger the tree, the higher the canker on the bole.

The infected trees usually died in about 3 years from the time the canker was noticeable. Some exceptions occurred when the canker was in the upper portion of the crown and the tree was able to make a recovery. Attempts to induce cankers artificially on young trees were unsuccessful.

DAIRY PLANT OPERATIONS OF COLLEGE DAIRY DEPARTMENTS

By T. I. HEDRICK and G. MALCOLM TROUT
DEPARTMENT OF DAIRY

INTRODUCTION

THE DAIRY MANUFACTURING undergraduate student at Michigan State University currently can get elementary experience in procurement, processing, storage, and limited merchandising of the common dairy products. These include market milk, ice cream and novelties, cheese, (including foreign types), butter, and dry milk. The graduate degree students have the opportunity to get practical experience at the supervisory level and earn an income at the same time.

The system symbolizes, "Science with Practice." This is in accordance with the Michigan Management Advisory Board, composed of a few of the leading managers of representative dairy plants in Michigan, which recommended emphatically that practical dairy plant experience be a requirement in the dairy manufacturing students' training program.

Since the college dairy plant opportunities and activities in the land-grant colleges were sufficiently wide in scope, a comparative analysis of the operation in various dairy departments seemed desirable. Such a study might reveal ideas for future planning of research, development, and instruction, not gained from the dairy routine operation of the local plant.

Questionnaires were sent to a staff member of the 43 dairy departments throughout the United States asking for specific information concerning the uses and operation of their college-operated dairy plant. Representatives from 37, or 86 percent, of the colleges responded.

The high percentage responding to this questionnaire was most gratifying. Only two dairy departments do not operate dairy plants in connection with their instruction. The data presented herewith,

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summarized from the questionnaires received from the 37 departments, apply specifically to the month of April, 1958. While the information was not confidential, tieing the data to specific institutions seemed to serve no real purpose.

RESULTS

Source of milk supply.

All the colleges with dairy departments maintain herds of one or more dairy breeds for class instruction. Milk from campus herd suffices for plant processing and distribution in some cases, but in others, milk was purchased for the needs beyond that furnished by the college herd. The source of the milk supply is shown in Table 1.

TABLE 1—Source of milk supply to college dairy processing plants

Percentage of milk furnished by college herd		Distribution of departments according to percentage of needed milk supply furnished by their own herd.	
		Number	Percent
Less than 25	(Average....18.66).....	4	10.8
25 to 49	(Average....30.34).....	6	16.2
50 to 74	(Average....59.37).....	8	21.6
75 to 99	(Average....86.00).....	9	24.4
100	100.00.....	10	27.0
	Total.....	37	100.0

The data show that approximately one-fourth of the dairy department herds furnish sufficient milk for college dairy plant requirements and that one-half of the department herds furnish more than 75 percent of their needs. Twenty-seven of the 37 departments reported the need of purchasing outside milk to supplement their own production sometime during the regular school year. The milk production from 10 department herds seemed inadequate to meet processing requirements, which necessitated the procurement of more than one-half of their supply from outside sources.

Price paid for raw milk (3.5 percent basis)

The price paid by the departments, per cwt. of milk, varied widely depending presumably upon location and availability of supply.

In general, the college price was equal to or above that paid producers by the local milk dealers. Apparently, a few departments did not assign a specific price, if 100 percent of the milk were produced by the college herd. Of the 30 colleges purchasing outside milk, two, or 6.7 percent, paid less; 18 (60.0 percent) paid the same and 10 (33.3 percent) paid more than the local milk dealers paid for their milk. Three departments paid a premium of above $0.50 per cwt. The amounts were $0.51, $0.70, and $0.76 to campus and to off-campus producers. The price per cwt. of milk with 3.5 percent milk fat for April 1958, ranged from $3.18 to $6.58 with an average of $4.96.

Milk Containers

The study revealed that a variety of container materials of various sizes were used in packaging milk. Among the glass containers used were one-half pints, quarts, one-half gallons, and gallons. Paper cartons used were one-half pints, one-third quarts, quarts, and one-half gallons. Regular and/or dispenser multiple-gallon cans were of 10-, 20-, and 40-quart sizes.

Of the 37 dairy departments reporting, five packaged exclusively in glass, three only in cartons and one entirely in multiple-gallon cans. Twenty-seven departments packaged milk in one or more sizes of glass. Two departments used the gallon glass jug. Sixteen used paper cartons. Twenty-seven used the multiple-gallon cans, of which eight included the dispenser type.

Six of the plants packaged milk in all three types—glass, paper, and cans. Eight packaged both in glass and cartons. Fourteen packaged in glass and multiple-gallon cans and five packaged in cartons and multiple gallon cans.

Selling price of milk to campus outlets

The selling price of milk in various sized packages and containers, as well as the larger local dairy wholesale prices are shown in Table 2. Data showed a wide variation in the selling price of college milk regardless of the package unit. Considering the variation in the cost of milk production in different sections, such a range in price might be expected.

The relationship between cost of raw milk and selling price was not close for one-half pint units. However, this relationship was slightly better between quarts and gallons.

TABLE 2—The unit selling price of college dairy and local distributor processed beverage milk

Unit	The unit selling price (cents) of milk by:				
		College dairies to campus dormitories, union, etc. in		Local dairies wholesale in	
		Glass	Paper	Glass	Paper
One half pints ..	Average..	5.90 (24)(*a*)	6.10 (14)	6.11 (25)	6.46 (30)
	Range...	3.6—10.0	4.8—7.5	4.8—8.3	4.8—8.3
Quarts.....	Average..	20.20 (24)	19.80 (12)	21.77 (25)	21.46 (29)
	Range...	13.9—24.0	17.0—24.0	18.0—27.0	18.0—25.5
Gallons(*b*)	All milk.....	Average..74.32 (25)		77.98 (22)	
		Range...75.0—91.0		44.0—94.0	
	Dispenser milk.....	Average..77.88 (8)		88.80 (5)	
		Range...68.0—94.0		76.0—96.0	

(*a*) Figures in parentheses indicate the number of dairies involved.
(*b*) No one-gallon containers indicated; sales were mostly in multiple-gallon cans.

The fat content did not appear to be closely related to the selling price. The replies to the question regarding fat content of the regular milk for campus distribution revealed one plant distributing at 3.4 percent, 14 at 3.5 to 3.7 percent, 21 at 3.8 to 4.0 percent; and one at 4.5 percent.

In general, the department price to dormitories and other campus outlets was the same or less than the local diaries' wholesale price. This was true regardless of size or type of container.

Operating margin on milk (difference between raw milk price and fluid milk selling price) in regular multiple-gallon containers ranged from 24.0 to 43.2 cents with an average of 32.7 cents per gallon. The lowest operating margin in multiple-gallon dispenser cans was 22.2 cents per gallon and the largest was 49.4 cents or more than twice the lowest. The arithmetic average was 35.8 cents. The operating margin on one-half pints was substantially greater than that for larger units.

This margin for a gallon quantity of milk in one-half pint cartons varied from 34.3 to 67.5 cents with an average of 54.8 cents. The average margin for milk in glass one-half pints showed an average of 50.9 cents with the tremendous range of 9.8 cents to 118.9 cents per gallon quantity.

Dispensers and Vending Machines

Of the 37 college dairies reporting, only eight indicated sales of milk through dispensers either in the dormitories or in other campus outlets.

Products Processed

In order to provide adequate training of dairy manufacturing students, college dairies as a whole are usually equipped to process other products than beverage milk. To be expected, some of the operations are quite limited. Nevertheless, the operation keeps management abreast of the problems specific to the several projects as well as indicating needed research. The scope of college major dairy product processing is shown in Table 3.

TABLE 3—Major products processed in college plants other than those processed specifically during class instruction

Rank	Name of product	Number of colleges reporting which process various dairy products	
		Regularly	Occasionally
1	Market milk	37	0
2	Ice cream	32	4
3	Cottage cheese	21	5
4	Orange drink	12	4
5	Butter	9	13
6	Cheddar cheese	9	8
7	Condensed milk	8	12
8	Cheese—other than Cheddar	8	12
	a) Blue	6	1
	b) Swiss-type	4	1
9	Dry milk	1	4

In addition to class exercises, virtually all the college dairy plants regularly processed beverage or market milk and one or more related products such as creams, sour cream, buttermilk, chocolate milk, beverage skimmilk, and yogurt. Thirty-two of the 37 departments reporting regularly manufactured ice cream. Four manufactured ice cream occasionally. Twenty-one plants made cottage cheese regularly and five only occasionally. Only nine college dairy plants churned butter regularly while 13 reported an occasional churning.

Surprisingly, orange drink commanded more attention in college dairies than might be anticipated. Twelve departments processed

orange juice regularly and four only occasionally. Concentrated milk (eight regularly and 12 occasionally) received as much attention as Cheddar cheese (nine regularly and eight occasionally). Eight college plants made cheese other than cottage and Cheddar regularly. Three or less reported the manufacture of Blue cheese spread, Bockstein, Brick, Colby, Cream, Edam, Frankenmuth type, Gouda, Monterey, Neufchatel, Smoked (Cheddar), trappist and other cheese or cheese products either regularly or occasionally.

Disposition of College Dairy Sales Income

Often the disposition or use of income from the sale of dairy products processed in college dairy plants is a delicate subject. Some department processing plants operate on a specific budget. Profits or losses are credited to the operation, but all returns go into a general fund.

The response to the questionnaire indicated that college dairies operate under several systems in respect to finances. However, two methods of handling finances generally prevail.

One: The data showed that 26 college dairy plant sales incomes were held within the department, usually by means of a revolving dairy plant (creamery) fund.

Two: Eight were required to turn the income over to a fund within the institution. One department had to release its income to the state account. Two departments had special arrangements whereby both the dairy department and the institution received portions of the income.

TRENDS SHOWN BY THE SURVEY

The questionnaire seemed to reveal more gradual changes in the operation of college dairy plants than has occurred in many companies within the industry. However, college plant changes do reflect certain major shifts which have occurred industrywise. The list includes:

a) Switch from creamline to homogenized milk.
b) Increase in tendency to standardize market milk at a lower fat content.
c) Greater use of cartons for packaging milk.
d) A shifting to the multiple-gallon containers, including the dispenser type.

e) Declining interest in butter manufacture.
f) Increasing volume of orange juice drink.
g) Greater interest in cottage cheese and concentrated milk.
h) Development of a wider variety of cheese.

College dairy plants as a group may not be classified as old established institutions. Yet, they have operated over a sufficient period of time to experience shifts of emphasis in operation. At one time a major dairy plant operation was butter manufacture. This has now given way to market milk and ice cream. Judging from responses to the questionnaire, considerable interest is being shown today in cottage cheese making. There seems to be a trend also to direct thinking more and more toward the development of cheese varieties.

Most striking changes noted in this survey, however, were the virtually complete shift from creamline to homogenized milk. Twenty-five years ago not a single college dairy processing plant was homogenizing even a portion of its milk supply. As indicated by the returned questionnaire, college plant after plant today is homogenizing 100 per cent of its beverage milk. In fact, only one college creamery reported not homogenizing any of its bottled milk. With homogenization came paper containers as a package for milk, especially one-half pints by many of the colleges.

SUMMARY AND CONCLUSIONS

Forty-three land-grant colleges offering curricula in dairy manufacturing were questionnaired concerning operational details of their dairy products processing plants. Data from 37 respondents showed that:

a) Only one-fourth of the dairy department herds furnished sufficient milk for the requirements of their dairy products processing plants and 72 percent had to purchase milk from outside sources.
b) The price per cwt. paid for 3.5 percent milk varied widely, depending upon availability and location of supply, but generally was equal to or above that paid producers by local milk dealers.

c) No set pattern prevailed for size and material of milk containers used. Of the 37 departments reporting five packaged in glass, three in paper and one in multiple-gallon cans, exclusively.

d) The operational margin on milk varied markedly among institutions and, generally, was greater with the smaller-unit packages.

e) About one-fifth of the college dairy processing plants sold milk, in part, through dispensers.

f) Market milk, ice cream, and cottage cheese were the three dairy products most frequently processed; orange drink was sold by one-third of the plants; butter and Cheddar cheese was made regularly in one-fourth of the plants; while, other varieties of cheese, condensed and dry milk were manufactured in fewer college dairy plants.

g) Seventy per cent of the departments reported that they retained the income from their plant sales as revolving funds within their own department.

Since virtually all land-grant colleges offering a dairy manufacturing curriculum processed dairy products, especially market milk and ice cream, regularly, consideration might be given to processing a wider variety of dairy products. This would be in the interest of better student training, research and service in the dairy industry. College dairy plants should set the example in maintaining quality, sanitation and efficiency of operation. Each college dairy should re-evaluate its purpose periodically and especially before planning to process non-dairy products.

VARIATION IN SUMMERTIME RAINFALL IN SOUTH-CENTRAL MICHIGAN

By A. H. EICHMEIER, R. Z. WHEATON and E. H. KIDDER[1]

SUMMERTIME STORMS often produce large amounts of precipitation in short periods of time. The amount received may vary greatly within short distances. Locations only a few miles apart could be suffering from flood and drought simultaneously.

Records obtained from the dense network of recording raingages on Sloan and Deer Creek watersheds[2] project (16 recording gages in 1956-57 and 22 recording gages in 1958) covering an area of 26 square miles, show the extent of this variation. Four storms have been selected as examples which show large differences in rainfall over this area.

Fig. 1 shows the distribution of rainfall occurring in the storm of August 9, 1956. Most of this rain fell in a two-hour period. In a distance of 6.5 miles, rainfall varied from a total of 2.70 inches to 0.09 inch. A storm of similar distribution occurred on August 18, when the heaviest and lightest amounts were 1.70 inches and 0.13 inch, respectively.

The July 4, 1957, thunder storm (Fig. 2) produced rainfall amounts ranging from 2.75 inches to 0.92 inch. The distance between these two gages was 6.75 miles. All of this rain occurred in a three-hour period starting at about 5:45 p.m.

The July 11, 1957, precipitation occurred in three different periods: 2-4 a.m., 6-8 a.m., and 3-7 p.m. The afternoon storm was of the greatest intensity, producing total amounts of 2.00-3.00 inches in the north, decreasing to totals of about 1.00 inch in the south. When the amounts recorded in the morning storms are added, the 24-hour totals (Fig. 3) range from 3.88 inches to 1.80 inches. The distance between these gages was 8.25 miles.

[1]State Climatologist, Michigan, United States Weather Bureau; Instructor; and Associate Professor, respectively, Agricultural Engineering Department, Michigan State University.
[2]Located in Ingham County, Michigan, approximately 12 miles southeast of East Lansing.

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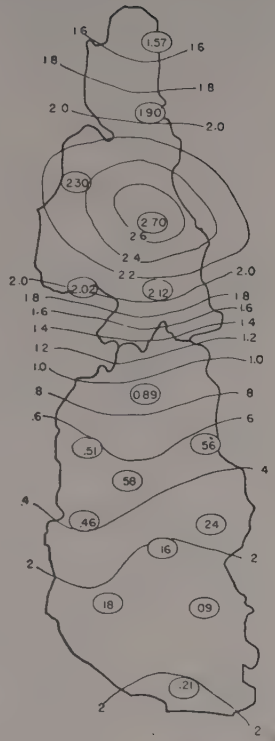

Fig. 1. Sloan and Deer Creek watersheds. Rainfall distribution for Aug. 9, 1956.

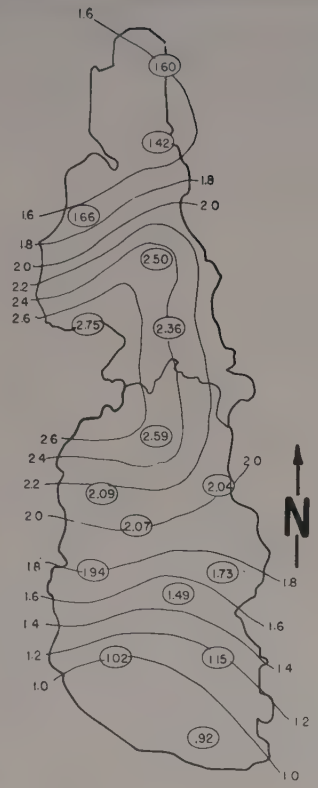

Fig. 2. Sloan and Deer Creek watersheds. Rainfall distribution for July 4, 1957.

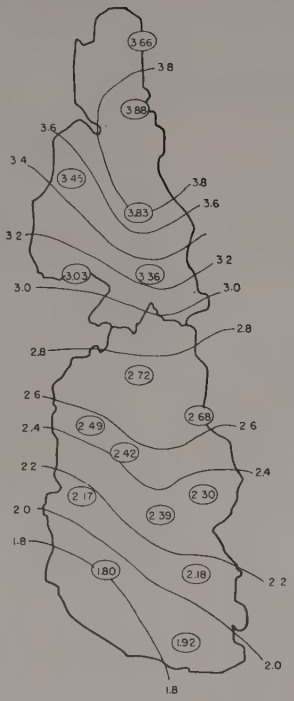

Fig. 3. Sloan and Deer Creek watersheds. Rainfall distribution for July 11, 1957.

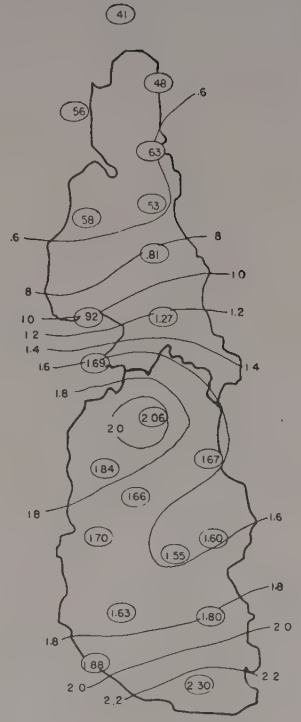

Fig. 4. Sloan and Deer Creek watersheds. Rainfall distribution for Aug. 6, 1958.

The three storms previously discussed showed a concentration of rainfall in the northern and central part of the area. This might lead to the conclusion that topography was a cause of this variation. An appraisal of the topography does not justify this conclusion. It is believed that a longer period of records will show that no one gage consistently receives the highest amount of precipitation. This is further borne out by the fact that the storm of August 6, 1958, (Fig. 4) produced rainfall varying from 2.30 inches in the extreme south to 0.41 inch at a station 12 miles to the north.

The previous discussion points up the great variation in the summertime distribution of rainfall. It indicates that the informed farmer will want a raingage of his own. If he is an irrigation farmer it is imperative that he have accurate rainfall information for his farm.

SUMMARY AND CONCLUSION

1. Four selected intense storms from a three-year period show the variation in distribution of summertime rainfall. Probably over a longer period of time, even greater variations will occur.
2. A close study of the difference in rainfall recorded at each gage in the accompanying figures shows that a dense network of recording raingages is necessary to measure this great variability in summertime precipitation.
3. In the area discussed, no portion would be expected to consistently receive the largest amounts of rainfall.
4. Fig. 1 and Fig. 4 illustrate the wide variation in distribution of summertime rainfall. Extremely wet to flood conditions exist in one part of the watershed while dry conditions continue in another part of the area.
5. This variation as shown by the figures emphasizes the importance of each farmer having a raingage in order to know how much precipitation has been received at his farm.

PRELIMINARY REPORT OF EXCESSIVE PRECIPITATION OVER SLOAN CREEK BASIN, A SMALL WATERSHED

By A. H. EICHMEIER, R. Z. WHEATON and E. H. KIDDER[1]

THERE ARE ESSENTIALLY two types of rainfall received during the crop season in Michigan. These are: (1) the steady, quite uniform and widespread rains occurring during the approach of warm fronts with stable air masses; and, (2) the showery, or thundershower type, which develops in connection with unstable air masses or the passage of cold fronts and squall lines.

In the latitude of Michigan, the former type occurs mainly in the early and late parts of the growing season and sometimes results in large rainfall totals over a period of two or three days. Most of the summer season rainfall comes from showers and thundershowers. These storms sometimes become excessively heavy for short durations, and may produce large runoffs overloading drainage systems.

The design of water management facilities is based on past records of rainfall. Since 1888, the Weather Bureau has maintained a network of cooperating stations spaced 20 to 30 miles apart, for the purpose of determining the climate of the various states. These stations serve very well except that summertime distribution of rainfall is very irregular and the complete pattern may not be revealed by their records. Some of the intense storms may pass between the stations and thus are not recorded.

To better determine the hydrology of agricultural areas in southern lower Michigan, a research project was established on the Sloan and Deer Creek watersheds in Ingham County through the cooperation of the Agricultural Engineering Department at Michigan State University; United States Weather Bureau; United States Geological Survey; Michigan Water Resources Commission; and Michigan

[1]State Climatologist, Michigan, United States Weather Bureau; Instructor; and Associate Professor, respectively; Agricultural Engineering Department, Michigan State University.

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Weather Service. Continuous precipitation and runoff measurements and periodic sediment measurements are made by the various agencies. Sixteen recording rain gages were initially installed in April of 1956 in the approximately 26-square-mile area of the two adjoining basins. In April 1958, six additional recording gages were installed.

This report is limited to the excessive rainfall periods recorded in the 9.34-square-mile area of the Sloan Creek Basin, Fig. 1. This watershed is located approximately nine miles southeast of East Lansing, Michigan. In Michigan, an excessive rain is defined as rainfall in which the depth of the precipitation in inches equals or exceeds

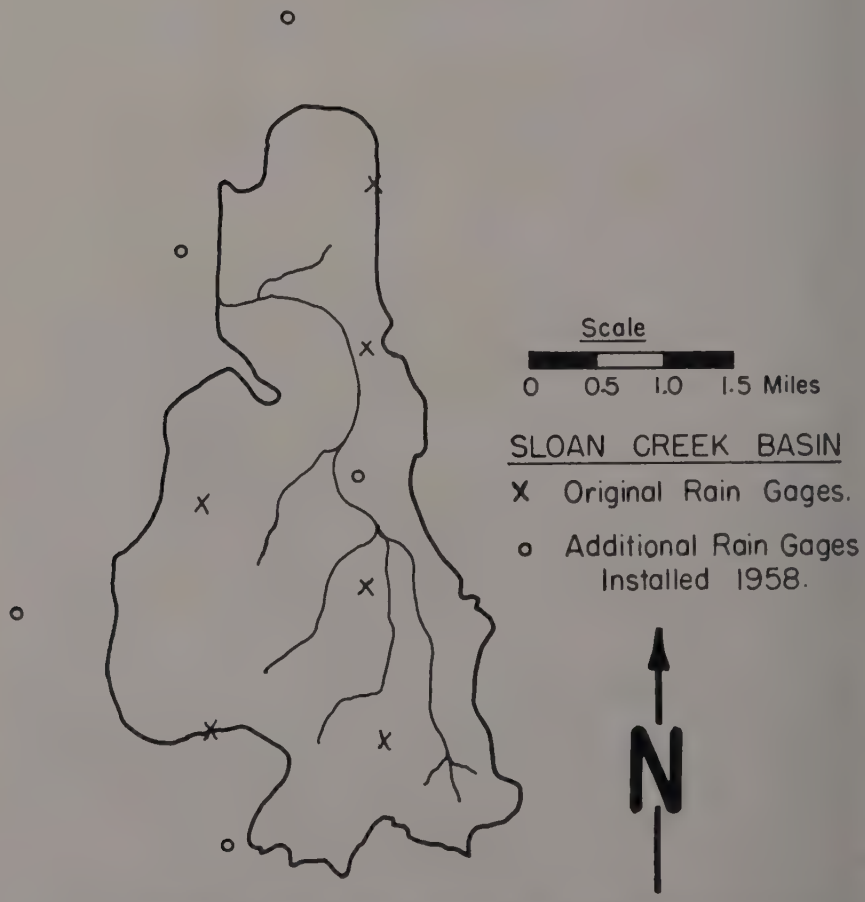

Fig. 1. Excessive rainfall periods recorded in the 9.34-square-mile area of the Sloan Creek basin.

.20 plus .01 per minute for any time period from 5 minutes to 3 hours. Table 1 shows (1) the highest amount received in any gage from 1956 through 1958, and (2) the average value of the excessive precipitation recorded for ½, 1, 2, and 3 hours by the six gages in the area for the period 1956 through 1957, and for the 11 gages in 1958.[2] Average values are used for comparison with long-time point records available at East Lansing's first order Weather Bureau Station.

TABLE 1—Sloan Creek basin—excessive precipitation totals (inches) for the dates and time periods shown

Date	Highest gage—hours				Average of 6 gages—hours			
	½	1	2	3	½	1	2	3
5/12/56.....	.90	.95	1.10	1.18	.78	.86	.97	1.05
8/5/56.....	.79	.79	.80	.80	.63	.64	.65	.66
8/9/56.....	1.92	2.50	2.55	2.55	1.47	2.00	2.07	2.07
7/4/57.....	1.31	1.51	2.75	2.75	.90	1.21	2.04	2.05
7/8/57.....	.68	.73	.87	1.00	.61	.68	.82	.96
7/11/57.....	.49	1.24	2.09	2.71	.38	.86	1.73	2.32
					Average of 10 gages			
7/4/58.....	1.35	1.37	1.37	1.38	.69	.71	.71	.72

The August 9, 1956, storm average of excessive precipitation for the six stations in Sloan Creek Basin was exceeded only once (July 7, 1923) at East Lansing since records began in 1910. Frequency analysis of rainfall indicated that this intensity for 1 hour's time (2.00 inches per hour) would occur about once in 35 years.[3] The highest single gage catch of 2.50 inches in an hour exceeds any recorded by the East Lansing Weather Bureau gage.

The period from July 4 through 11, 1957, is of great interest because three excessive storms occurred during this 8-day interval. Table 2 shows (1) the daily rainfall amounts, (2) averages, and (3) the totals for the six gages during this time. The probability of occurrence of this much (6.82 inches) in 8 days is about once in a hundred years as determined by a study of past weather records tabulated at the East Lansing Weather Bureau. The average excessive precipitation for the standard time periods in use by the Weather

[2]For the one excessive storm which occurred in 1958, one gage was inoperative.
[3]East Lansing analyses by method of extreme values, after Gumbel.

TABLE 2—Precipitation totals in inches for individual gages in Sloan Creek basin, July 4-11, 1957

Gage number	July								Total
	4	5	6	7	8	9	10	11	
1	1.60		.02		1.44			3.66	6.72
2	1.42		.01		1.30			3.88	6.61
3	1.66		.03		1.08			3.45	6.22
4	2.50		.01		1.19			3.83	7.53
5	2.36		.04		1.10			3.36	6.86
6	2.75		.05		1.13			3.03	6.96
Average.	2.05		.03		1.21			3.54	6.82

Bureau is shown in Table 3 for the three individual storms. Taken individually, no extremely high totals for the time periods were recorded in these storms. The period of occurrence of the 3-hour totals would be about once in 10; once in one; and once in 25 years,[3] respectively, for the three storms. The probability, however, of such a combination is the product of the above values, or once in 250 years.

Of additional interest, a disproportionately large percentage of the rainfall on July 11 ran off because of the high soil moisture content produced by the preceding storms. Previous to the July 4 storm, the antecedent precipitation index was low, with soil in a condition to absorb considerable water. Runoff from the July 4 and July 8 storms was low, with peak stream flows of about 10 cfs/sq. mi., and 7 cfs/sq. mi., respectively. The peak flow from the July 11 storm was 74 cfs/sq. mi.[4] and the stream depth was the greatest recalled by local residents. None of the other excessive storms listed in Table 1 produced runoff approaching this magnitude.

[3]Op. cit.
[4]Data from United States Geological Survey.

TABLE 3—Excessive precipitation totals in inches for days and time periods shown; average of six gages in Sloan Creek basin

July 1957	MINUTES										
	5	10	15	30	45	60	80	100	120	150	180
4	.09	.24	.53	.90	1.03	1.21	1.45	1.96	2.04	2.05	2.05
8	.12	.28	.48	.61	.65	.68	.71	.77	.82	.86	.95
11			.18	.38		.86			1.74		2.33

This preliminary analysis is based on 3 years of record. It is expected that these measurements will be continued for at least 10 years. A comparison of precipitation occurrences made in this article are between the averages of the gages in the watershed and the point totals, i.e., one gage totals, recorded at the East Lansing Weather Bureau Office.

For more complete information on the general project in the Sloan-Deer Creek basins, including soils, cropland, runoff, sedimentation and map, see Report No. 1, entitled "Hydrologic Studies of Small Watersheds in Agricultural Areas of Southern Michigan," published by the Water Resources Commission, State of Michigan.

CONSUMER ATTITUDES AND BEHAVIOR TOWARDS FROZEN MEATS

By GLEN W. HIGGINS[1] *and HAROLD M. RILEY*
DEPARTMENT OF AGRICULTURAL ECONOMICS

INTRODUCTION

THIS STUDY was an attempt to determine some of the behavior patterns and attitudes of consumers toward frozen meats. Some persons believe that distribution of frozen meats from the packer to the consumer could result in economies in the meat industry and an overall reduction in costs of marketing meats. However, consumers have been reluctant to accept commercially frozen red meats as satisfactory substitutes for the more familiar fresh meat items.

During the week of April 7, 1958, a personal interview survey of 436 households was conducted in the suburban residential area surrounding Detroit. The purpose of the survey was to obtain information on consumer acceptance of frozen meats. The specific objectives were as follows:

(1) To determine meat shopping habits as they relate to frozen food storage in the home.

(2) To determine the extent to which shoppers have had experience with frozen meat items.

(3) To determine the degree of satisfaction or dissatisfaction with specific meat items.

(4) To find out how consumers rate frozen red meats with respect to flavor, tenderness, cost and convenience, when compared with fresh meats.

SURVEY PROCEDURES

A 4-page schedule was prepared in consultation with subject matter specialists in various departments at Michigan State University.

[1]Formerly instructor in the Department of Agricultural Economics.

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This schedule was pretested and revised following the pretest. A supplementary schedule was also developed for households having home freezers or renting frozen food lockers.

Five suburbs in the Detroit metropolitan area were selected as being generally typical of "suburbia", the rapidly expanding residential areas which encircle the larger cities. These areas are characterized by rapid post-World War II development. Single family dwellings predominate, with shopping centers geared to a highly mobile population.

The five suburbs, Roseville, Royal Oak, Livonia, West Dearborn and Lincoln Park, were selected after studying 1950 census tract data and data assembled by **The Detroit News** in a 1956 survey. These suburban cities are located in a semicircle about the city of Detroit and are populated by medium to above average income, non-colored families (See Table 1).

TABLE 1—Economic characteristics of five Detroit suburban areas

Suburb	Estimated 1957 population	Number of houses		Average family income 1956	Median home value 1950
		1950	1957		
				dollars	dollars
Roseville	37,200	4,257	10,400	6,200	6,980
Royal Oak	71,500	13,284	21,000	7,800	10,764
Livonia	46,000	4,832	13,100	6,900	8,988
West Dearborn	58,000	11,396	16,300	8,400	11,815
Lincoln Park	46,500	8,135	13,400	7,400	8,444

Source: Population, Housing and Economic Characteristics of the Detroit Standard Metropolitan Area—1957, prepared by the Promotion and Research Department of the *Detroit News*.

An area probability sampling procedure was used in selecting the households to be surveyed. Detailed maps prepared by the Detroit Edison Company were used in preparing the sample. Ten clusters of 11 houses each were randomly selected in each suburb in anticipation that this would yield a net sample of 100 completed schedules from each area. Although interviewers made up to three call backs, including evening calls, only 436 schedules were completed and in two areas an additional cluster was added to the sample. The field interviewing was done by nine students who were recruited through the Department of Home Economics at Wayne State University (Detroit).

Frozen Food Storage Space In The Home

The results of this survey indicate that frozen food storage space in suburban homes may not be a critical factor limiting present purchases of commercially frozen meats. All of the homes surveyed had one or more mechanical refrigerators. Three-fourths of the homes had refrigerators with across the top frozen food storage space or two-door refrigerator freezer combinations (Table 2).

TABLE 2—Percentage of households having various types of refrigerator frozen food storage, Detroit suburban area survey, 1958

Type of frozen food space	Percent of households
One-door refrigerator with ice cube compartment only	22
One-door refrigerator with frozen food storage across the top	64
Two-door refrigerator freezer combination	14
Total	100

Eleven percent of the households had a home freezer in addition to their refrigerator. Only three families in the total of 436 were renting a frozen food locker. The percent of families having home freezers varied significantly among suburban areas.[2] In the lower income suburbs of Roseville and Lincoln Park only 3 percent of the families owned home freezers while in the three other suburbs the proportion having freezers ranged from 13 to 17 percent.

Meat Shopping Patterns

The most common shopping pattern in the suburban areas studied was to buy meat once a week. Fifty-six percent of the households follow this practice. Another 16 percent shop irregularly but less than once a week. Eleven percent made one major shopping each week but made fill in purchases during the week. Only 16 per cent of the families made two or more major shoppings weekly.

Generally, the higher the family income, the more frequently households shopped for meat. It was also found that home-freezer owners shopped less frequently for meat than families with only a refrigerator.

[2]Chi-square tests were used in this study to evaluate significance of various relationships.

One of the most important findings of this survey was that *82 percent of the homemakers said they were buying "fresh meats" and holding them in the frozen food compartment of their refrigerator.* Over three-fourths of these homemakers were holding this meat less than two weeks.

Families following this practice of freezing fresh meats shop less frequently for meats than families not following the practice. Therefore it appears that this is a means of extending the shelf life of "fresh" meats so as to avoid shopping more than once a week.

Experiences In Purchasing Frozen Meats

All respondents were asked to indicate their purchase experience for 17 frozen meat items. The response was in terms of one of the following: Have never purchased; tried but no longer buy; or tried and buy occasionally (See Table 3).

TABLE 3—Reported purchase experience with frozen meat items, Detroit suburban area survey, 1958

Item	Have never purchased	Tried but no longer buy	Tried and buy occasionally	No answer	Total
	percent	percent	percent	percent	percent
1. Meat pies	22	24	54	—	100
2. Tray dinners	56	19	24	1	100
Poultry					
3. Turkeys	36	4	59	1	100
4. Chicken, fryers	52	6	41	1	100
5. Chickens, roasting	52	6	41	1	100
Beef					
6. Cubed or chopped steaks or steakettes	42	13	44	1	100
7. Steaks	76	6	15	3	100
8. Ground beef patties or hamburger	63	8	28	1	100
9. Roasts	81	4	12	3	100
Veal					
10. Cutlets	86	3	8	3	100
11. Breaded cutlets	86	4	9	1	100
12. Roasts	90	2	7	1	100
Pork					
13. Chops	81	4	14	1	100
14. Breaded chops	91	2	4	3	100
15. Roasts	89	2	7	2	100
16. Sausage	88	1	10	1	100
17. Frozen fish or seafood	21	4	74	1	100

Frozen fish or seafood, turkeys, meat pies, chopped beef steaks and chickens were the items that have apparently attained the greatest degree of consumer acceptance. The proportion of households that have tried and buy occasionally ranges from about 41 up to 74 percent on these items (Table 3).

The percentage of families that have tried but no longer buy is an indication of the dissatisfaction with particular frozen meat products. Meat pies, tray dinners and chopped beef steaks are items where dissatisfaction is higher than for other items. However, these are also items that a relatively high percentage of the families have tried.

A high percentage of families said they had never tried the frozen red meat items, such as steaks, roasts and chops. On individual items the proportion of families who said they had never purchased ranged from 76 up to 90 percent (Table 3). Only 45 percent of the families had purchased any of the frozen roasts, steaks or chops in the beef, veal and pork categories.

Following the enumeration of purchase experience, as summarized in Table 3, all respondents were asked two open-ended questions to determine the nature of their experiences with these frozen products. The first question was, "If there are any frozen meats you have tried but no longer buy . . . briefly explain why you discontinued buying them." The second question was, "If there are any frozen meat items that you buy frequently . . . briefly explain what you like about them." The response to these questions are summarized in Tables 4 and 5.

Price was a principal reason for dissatisfaction although many housewives gave a specific example of a bad experience with a frozen item. "Quality" and condition of the product also were cited frequently as reasons for discontinuing purchases. Many housewives made specific references to the dislikes of individual members of their family for particular items.

Comments offered about frozen meat products purchased frequently emphasized convenience and quick preparation. Tenderness, trim of cuts, and storability were desirable features mentioned about frozen roasts, steaks and chops.

TABLE 4—Unsatisfactory frozen meat items reported and comments received, Detroit suburban area survey, 1958

Item	Number of mentions	Comments
Meat pies	73	Too small; meat tough; no taste; family didn't like; don't like without bottom crust; poor seasonings; too much gravy, expensive; and too spicy.
Tray dinners	59	Poor variety; just awful; too small; expensive; taste too drab; family didn't like.
Steakettes	44	Dry; bad cuts; can t see product; too thin; husband doesn't like; too dry; too much fat; and poor flavor.
Fish or seafood	28	No taste; loses flavor; tastes like iodine; no variety; rotten; and has strong flavor.
Ground beef patties	25	No flavor; too much water; poor taste; expensive; was bad; too thin; and too much fat.
Chicken	20	Got food poisoning; no taste; expensive; bone turns black when cooked; and rotten.
Breaded veal cutlets	15	Too much breading; dry; no flavor; tasteless; off odor; and mostly fat.
Beef roasts	14	Not available; off odor; expensive; fatty; poor flavor; not enough storage; and they shrink.
Beef steaks	12	Got food poisoning; flavor bad; expensive; don't like to thaw; needed much seasoning; greasy; and not available.
Pork chops	10	Poor flavor; expensive; tough; can't see product; no taste; too few in package; and quality degenerates after freezing.
Breaded pork chops	7	Do own breading; package too large; and not fresh.
Turkey	7	Poor taste; no storage; expensive; bruised; and poor flavor.
Pork roasts	5	Not right cut; bad flavor; no texture; poor color; and expensive.
Sausage	1	
Lamb chops	1	Strong flavor.
Total	321(*a*)	

(*a*) 436 households were contacted.

Attitudes Towards Frozen Meats

Near the beginning of the interviews each respondent was asked, "In general, how would you describe your feelings toward frozen meats as compared to fresh meat." This was an open ended question to obtain indications of attitudes toward frozen meats before the respondent was conditioned by a sequence of other questions.

Three classifications were used in analyzing the replies to the above question. The first classification summarizes the replies where a preference was stated or a direct comparison was made between

TABLE 5—Satisfactory frozen meat items reported and comments received, Detroit suburban area survey, 1958

Item	Number of mentions	Comments
Fish or seafood.....	125	Wider variety; flavor good; easy to use; economical; no fresh available; right size; can keep longer; good taste; always available; properly packaged; and looks better.
Meat pies.....	65	Convenient; easy to fix; quick; family likes; time-saver; good taste; complete dinner; and depends on brand.
Steakettes.....	54	Easy to prepare; quick meal; children like; good taste; good for sandwiches; reasonable price; good for emergencies; tasty; and attractive.
Chicken.....	52	Good; easy to prepare; tender; more readily available; easy to store; family favorite; well-cleaned; and good taste.
Turkey.....	47	Good taste; tender; easy to prepare; no fresh available; can store; convenient; and good flavor.
Tray dinners.....	21	Good; easy to fix; variety; no leftovers; children like; quick and easy.
Ground beef patties..	20	Tender; quick; easy to prepare; and good flavor.
Beef steak.....	17	Like frozen; tender; well trimmed; good flavor; and family favorite.
Beef roasts.....	16	Saves time; tender; well cut and trimmed; can store; and good taste.
Pork chops.....	13	Tender; convenient; well trimmed; and easy to fix.
Veal cutlets.....	7	Tender; and good taste.
Breaded pork chops..	4	Tender.
Sausage.....	4	Can store; convenient, and good flavor.
Veal roast.....	3	Convenient form.
Pork roast.....	1	
Total.....	449(*a*)	

(*a*) 436 households were contacted.

the two products. Of the 436 households, over 90 percent offered replies that could be summarized (Table 6). The largest percentage (42.9) simply said they preferred fresh meat. Only 8 percent stated a preference for frozen meats whereas 14 percent said they were both the same.

The second classification of responses to the general question about attitudes was a summary of things housewives said they disliked about buying frozen meats. Inferior quality of products was most frequently mentioned. Inconvenience of thawing meat before cooking, too expensive and cannot see the meat were other criticisms

TABLE 6—General statement of preferences, frozen as compared to fresh meat, Detroit suburban area survey, 1958

Statement of preference	Percent of households
Prefer fresh	42.9
Prefer fresh but take advantage of frozen specials	.7
Prefer to buy fresh, then freeze	6.9
Prefer fresh, haven't tried frozen	2.5
No experience with frozen	13.1
Both the same	13.5
Buy both, depends on price	.9
Prefer frozen	7.6
Some frozen good, some bad	2.3
No answer	9.6
Total	100.0

(Table 7). Fifty percent of the respondents made critical comments about frozen meat products.

Only 22 percent of the households volunteered favorable comments about frozen meats, of these statements nearly 60 percent concerned the convenience of frozen meat products. Another 20 percent referred to tenderness and flavor as desirable characteristics of the frozen items.

TABLE 7—Objections to frozen meat as compared to fresh meats, Detroit suburban area survey, 1958

Statement about frozen meats	Number of times mentioned by 436 respondents
Quality not as good—bad experience	64
Inconvenient thawing	51
Too expensive	42
Cannot see meat	34
Not fresh—"old"	23
Not enough home storage	21
Not available at store	20
Size of cuts not right	14
Too watery—wasteful	10

Other Comparisons Between Fresh and Frozen Meats

Those housewives who had tried at least one frozen item of heavier red meat cuts, such as chops, roasts, or steaks, were asked to make a comparison of fresh and frozen meat of the same cut and grade on four factors. These were flavor, tenderness, cost per serving, and convenience in preparation. Only 45 percent had purchased at least one of these items. The ratings are given in Table 8.

TABLE 8—Rating of fresh vs. frozen red meats by consumers who have tried frozen meats, Detroit suburban area survey, 1958

Comparative rating	Flavor	Tenderness	Cost per serving	Convenience in preparation
	percent	percent	percent	percent
No difference	35	40	22	25
Prefer fresh	44	20	36	20
Prefer frozen	10	25	19	46
No opinion	5	8	17	1
No answer	6	7	6	8
Total	100	100	100	100

Frozen meats were rated highest on convenience in preparation while fresh meats were preferred on flavor and cost per serving. No great difference was noted in the ratings on tenderness, although 25 percent of the homemakers thought frozen meats were more tender.

Purchase Patterns of Home Freezer Owners

Forty-five of the 436 households surveyed had home freezers. However, these were primarily concentrated in three suburbs, Royal Oak, Livonia, and West Dearborn. The average size home freezer was 13.5 cubic feet.

It was found that 16 percent of the home freezer owners do subscribe to some type of a "freezer plan." Almost 70 percent reported purchasing prepackaged fresh meat when featured as a special in retail stores and subsequently storing this meat in the home freezer.

In the previous six months' period, 16 households or 36 percent reported purchasing sides or quarters of beef for their home freezer. Nine purchased for cash and five made the purchase on credit. Pack-

ing houses and frozen food plants were the predominate source of these quantity purchases of meat, but five purchased directly from farmers.

In addition to buying prepackaged fresh meat at retail stores and buying sides or quarters of beef, there were very few other purchases or sources reported. Three reported small purchases or gifts from relatives and two reported purchases from farmers. Two others reported purchases from a butcher.

All home freezer owners were asked if they believed that their home freezer enabled them to reduce their expenditures for meat. While 62 percent answered yes to this question, 20 percent answered no, and 8 percent thought that it was nearly the same cost, but expressed the opinion that they "ate better."

Some Concluding Observations

Most consumers follow the practice of purchasing fresh meat and subsequently freezing it in their home refrigerators. This procedure makes possible once a week shopping which is typical in the suburban areas studied. This also suggests that homemakers do not have strong objections to "frozen meats" handled in this manner.

Frozen food storage space in the home does not appear to be a critical factor limiting present purchases of commercially frozen meats.

Over one-half of the consuming households have never purchased frozen roasts, steaks or chops. More than three-fourths have not purchased specific items of the frozen red meat cuts. This indicates a reluctance on the part of the consumer to even "give frozen meats a chance."

The prepared meat items, seafoods, sandwich meats and poultry have been tried by most consumers. Because of the consumer's more extensive experience with these products they are given both as the most satisfactory and the most unsatisfactory of the frozen meat items.

Convenience is a principal advantage associated with frozen meats; however, the inconvenience of thawing before cooking was frequently mentioned as an important disadvantage.

Principal criticisms of commercially frozen meats are: quality not as good as fresh meats, inconvenience of thawing, too expensive, and cannot "see" the meat.

This survey has provided some indications of consumer attitudes and behavior towards frozen meats from a representative sample of

households in the Detroit suburban area. Frozen red meats have been available in this area since 1955 when a large national packer made a concentrated effort to launch a complete line of frozen steaks, roasts and chops in the Detroit market. During 1957 and 1958 a large local retail chain also experimented with a line of frozen red meat cuts packaged in a transparent plastic dip. The high percentage of households that have not tried many of the frozen meat items has considerable significance in light of the market development that has occurred in the area surveyed.

The dissatisfaction with available frozen meat products, indicates that additional research should be conducted to determine the processing and handling practices which would improve product quality and reduce deterioration before sale. Continued studies of consumer attitudes and opinions are also needed to identify important problems in product design and merchandising procedures for frozen meats.

LABOR REQUIREMENTS FOR HERRINGBONE AND OTHER MILKING SYSTEMS

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THIS IS THE SECOND in a series of articles dealing with various aspects of the herringbone and other milking systems. The original study (Hoglund *et al.* 1959) included a detailed analysis of investments for 33 new herringbone and 22 other milking parlors on 55 Michigan dairy farms. During the course of the two studies more than 70 Michigan dairy farms were visited in order to establish the type of milking parlors constructed during the past few years. Nearly all of these milking systems were one of the 4 types illustrated in Fig. 1.

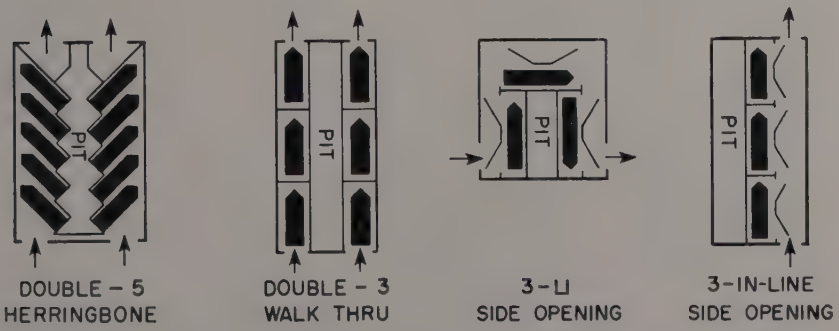

Fig. 1. These drawings illustrate the four types of milking systems studied.

PURPOSE AND PROCEDURE

The primary purpose of the present study was to determine the labor requirements for milking cows, and the related chores, in the herringbone as well as 3 other types of milking parlors.

[1]The authors acknowledge assistance from L. H. Brown of the Department of Agricultural Economics in organizing the timing phase of the study. The authors also wish to express their appreciation to the dairy farmers who cooperated in the study.

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A total of 42 dairy farms were selected for stop watch time and motion studies of the milking operation. Many of the same farms used for the investment study were also used for this study. Some of the new herringbone parlors were not in operation long enough to have an established milking routine and thus were not used in this labor study.

Complete time and motion studies were made for 25 herringbone and 17 other milking parlors. A total of 71 milkings were timed and analyzed. These data were used to determine the labor requirements.

In order to establish the need for timing more than one milking for each farm consecutive milkings were timed on 11 farms. On 6 farms 4 consecutive milkings were timed and on 5 others 2 consecutive milkings were timed. For one of these farms 8 milkings were timed by 4 different persons. This included 4 consecutive milkings by one person, 2 consecutive milkings by another person and 2 individual

Fig. 2. All of the operations in a complete milking cycle were timed and recorded for 42 farms. The operations timed included bringing cows in, washing udders, feeding grain, milking, irregular jobs, and letting cows out.

milkings by 2 others. The average milking rate for these 8 milkings was 42 cows per hour with a variation of 41 to 44 cows.

The timing of consecutive milkings on the same farm with the same person doing the milking did not produce an appreciable difference in the milking rate. Thus 31 single milkings were timed and analyzed for the other 31 farms included in this study.

The 25 herringbone parlors included in this study consisted of 17 double 6 stalls, 1 single 6 stall and 7 of the double 4 and double 5 size. Since nearly all of the first herringbone installations in Michigan were double 6 stalls not many of the other sizes were available for timings. There were only 7 double 4's and double 5's available for study and none of the double 8's were in operation long enough to be included.

Most of the walk-through parlors studied were double 3 installations with 3 stalls on each side. A few dairymen were operating double 2 and double 4 walk-through parlors.

The U shape side-opening parlors studied were predominately 3 and 4 side-opening stall arrangements. Two of these parlors had 5 stalls. The in-line side-opening parlors ranged from 3 to 7 stalls on one side to 2 to 4 stalls on each side of the pit. A few in-line side-opening parlors were equipped with a "prep" stall. This stall was used to prepare a cow before being let into a regular stall for milking.

In order to arrive at a standard for comparing the 4 parlor types it was necessary to make a complete breakdown of the total milking time into individual operations. The total time for each operator and the total time for each machine was accounted for.

The time required for each operation was converted to a standard 50-cow herd. The average number of cows milked per day for the herringbone parlors was 66 while the average for the other type parlors ranged from 40 to 47 cows. Based upon these herd sizes the 50-cow herd standard provided a good basis for comparing the 4 parlor types.

MILKING PARLOR EQUIPMENT

The kind and combination of equipment used affected the time required to perform various milking jobs. Detailed information was obtained for each farm on the specific equipment installed.

All the milking parlors studied were equipped with pyrex or stainless steel pipe lines. Some of the milker systems were operated

with automatic or semi-automatic pipe-line washers. Three farms had automatic bulk tank washers.

All of the herringbone systems and most of the other milking parlors were equipped with mechanical grain feeding systems, either gravity or auger. There were fewer operational problems with gravity feeders. Grain feeding was controlled at a central panel for most of the herringbone systems and for a few of the walk-through systems. Grain feeding in the side-opening parlors was controlled at each stall.

One milking machine was used for each 2 stalls in the double herringbone and the walk-through parlors. These milker units were transferred to the other side of the pit when a new batch of cows was brought in. For the side-opening type parlors, one milking machine was generally used for each stall although a few systems had one milker unit for each 2 stalls.

HOLDING PENS AND ENTRANCE ARRANGEMENTS

Holding pens adjacent to the milking parlor had been constructed on all but two of the farms studied. Several dairymen used a "hot wire" controlled by a rope from the milking room to save labor in bringing cows in from the holding area. Usually, the hot wire was not used every day. On one farm this device was used about once every two weeks to remind the cows to move toward the parlor entrance door.

Some of the parlors were designed to allow the cows to enter practically on the ground level, with the floor inside the building being 3 to 4 inches above ground level to prevent drainage into the building. These proved to be the most troublefree. However, where pit drainage required the cows to be elevated above ground level, steps (not exceeding 8″ in height) proved to be most satisfactory at both entrance and exit. On several farms, cows had considerable difficulty in walking up and down ramps, particularly when the concrete was wet or covered with ice.

MILKING OPERATIONS

In the herringbone and walk-through parlors cows were handled in groups. This group handling permitted certain operations to be performed once for the entire group. In the side opening parlors cows were handled individually and nearly all operations were done separately. See Table 1 for the physical differences in the 4 milking parlor types.

Fig. 3. A holding pen constructed of portable gates or a "hot wire" reduces the time in getting cows into the milking parlor.

TABLE 1—Physical differences in 4 milking parlor types—One man milking and one size parlor for each type

Operations	Double 5 herringbone	Double 3 walk-thru	3 U side-opening	3-in-line side-opening
	2 outside doors 2 inside gates	2 outside doors 4 inside gates	2 outside doors 2 inside gates	2 outside doors 2 inside gates
LETTING COWS IN AND OUT	4 Total—doors and gates to operate for 5 cows, or 1 DOOR OR GATE PER COW	6 Total—doors and gates to operate for 3 cows, or 2 DOORS OR GATES PER COW	4 Total—doors and gates to operate for each cow, or 4 DOORS OR GATES PER COW	4 Total—doors and gates to operate for each cow, or 4 DOORS OR GATES PER COW
FEEDING GRAIN	Feed all 5 cows at once at a central panel NO MOVING	Feed all 3 cows at once at a central panel or individually(*a*)	Feed individually MOVE FOR EACH	Feed individually MOVE FOR EACH
WASHING UDDERS	Pick up hose and wash all 5 cows in line. Times picking up hose: 1 FOR 5 COWS	Pick up hose and wash all 3 cows in line. Times picking up hose: 1 FOR 3 COWS	Pick up hose and wash each cow individually. Times picking up hose: 1 FOR 1 COW	Pick up hose and wash each cow individually. Times picking up hose: 1 FOR 1 COW

(*a*) Most of the walk-through parlors were equipped with grain feeding controls at each stall, however, a central feeding panel was used in some walk-through parlors saving steps and time.

Regardless of the parlor type used, the majority of the dairymen followed a definite milking routine. The operations included in the milking procedure were:

1. Letting cows in
2. Feeding grain
3. Washing udders
4. Putting milkers on
5. Milking
6. Machine stripping
7. Taking milkers off
8. Lettings cows out

Pre-milking Operations

Letting cows in and out was a group operation for the herringbone and walk-through parlors performed while the milking machines were in operation on the other side. This saved time and steps and kept the idle machine time to a minimum. In contrast to this, in the side-opening type parlors each milking machine was idle while one cow was let out and another let in, fed, and washed. The 3-in-line side-opening parlor required 28 minutes to get the cows in and out while milking 50 cows. For the double 5 herringbone this time was only 14 minutes (see Table 2).

Feeding cows grain in all parlor types was usually done while the cows were coming in. The feeding operation was performed 50 times for 50 cows in the side-opening parlors but only 17 times in the double 3 walk-through and only 10 times in the double 5 herringbone when a central feeding panel was used. Since the feeding was usually done while the cows were coming in, the time for performing this operation was not tabulated separately.

Washing udders for 50 cows was an operation also affected by parlor type. In the side-opening parlors, the dairyman picked up a water hose 50 times, 17 times in the double 3 walk-through and 10 times in the double 5 herringbone. Washing udders required 19 minutes for the 3-in-line side-opening parlors and only 11 minutes for the double 5 herringbone parlors. In the herringbone and walk-through parlors, one hose for each side makes this operation possible for the entire side whereas, several hoses per side increases this job time. In contrast, the individually operated side-opening stall parlors were equipped with a hose at each stall for best efficiency. Wiping udders dry during extremely cold weather became an additional operation.

Milking Operations

Transferring milking machines in the herringbones and walk-through parlors was a continuous operation from a cow on one side of the parlor to the cow directly opposite. In the herringbone, this transfer of one milking machine required about 20 seconds with an average total time of 19 minutes for 50 cows. In the side-opening parlors, this operation required 30 minutes for the 50 cows (see Table 2).

TABLE 2—Minutes of man time used in performing various operations in milking 50 cows four parlor types

Type	Letting cows:			Wash udders	Transfer milkers	Machine stripping and adjusting	Irregular jobs (*a*)	Total(*b*) milking time	Comparative(*c*) milking time
	Into parlor	Out of parlor	Total						
	minutes	minutes	minutes	minutes	minutes	minutes	minutes	minutes	percent
Double 5 Herringbone	9	5	14	11	19	18	7	69	100
Double 3 walk-thru	12	7	19	14	25	20	7	85	123
3 U side-opening	17	8	25	16	29	22	7	99	143
3-in-line side-opening	19	9	28	19	30	29	12	118	171

(*a*) *Irregular jobs*: jobs which require time in the milking operation are treating cows, milking fresh cow into a separate milker unit, milker fell off, feed stuck, change filter pad, etc.
(*b*) Total milking time is for 50 cows from time first cow entered parlor to last cow leaving.
(*c*) The herringbone total time was considered as a base equal to 100 percent.

Machine Stripping, adjusting and checking, as shown in Table 2, was an inclusive time. The majority of the dairymen studied did some actual stripping. The time spent in machine stripping varied considerably, ranging from as high as 61 seconds per cow in one herd to no actual stripping in some herds. For all herds where machine stripping was done, the average was 31 seconds per cow. Those farmers who did not include machine stripping in their milking operation did spend some time in adjusting and checking the teat cup claws or pulling individual teat cups off prior to transferring the milking machine.

Irregular jobs, such as treating cows for some injury and changing filter pads were part of practically every normal milking routine as shown in Table 2. Therefore, these jobs were considered as part of the normal routine.

Handling Fresh Cows and Slow Milkers

The procedure used by most of the dairymen in milking fresh cows was to substitute a special milker unit for one of the regular pipe line milkers. Parlor type did not change this operation.

There was a tendency to cull slow milking cows from the larger herds in all types of parlors unless the cows were exceptionally high producers. Slow milking cows were handled with considerable flexibility in the herringbone parlors. First, the cows were in the parlor an average of 14 minutes, as compared to 7 minutes in the side-opening parlors (Table 4). Second, the close arrangement of cows allowed milking machines to be transferred to any one of 2 or 3 cows across the pit in the event that two slow cows were directly opposite each other.

For the walk-through parlors slow milking cows were more of a problem. The milking machines could be transferred only to the cow directly across the pit. Since the cows were in the double 3 walk-through parlors nearly 10 minutes, some adjustments were usually made without too much delay.

MILKING TIME

"Milker on" Time or the time the milking machines were actually on the cows was longer than is usually recommended. In a Cornell study for 286 cows the actual milking time ranged from 1 minute 15 seconds to 11 minutes 40 seconds per cow with an average of 3 minutes 33 seconds. This included 37 seconds of machine stripping (Stewart and Schultz, 1955).

In the Cornell study machine stripping was begun when the milk flow fell to 0.3 lb. or less every 15 seconds. When proper milking procedures were used, most cows were milked out in 5 minutes or less. Only 9 percent of the cows required more than 5 minutes to milk (Stewart and Schultz, 1955).

In the present Michigan study, more than 70 percent of the cows in the herringbone parlors and from 45 to 54 percent of the cows in the other 3 parlor types required 5 minutes or more to milk (Table 3). The milking machines were on the cows 8 minutes or more for 17.2 percent of the cows milked in the herringbone parlors. This percentage ranged from 6.6 to 13.6 for the other 3 parlor types. These figures indicate that the milking machines were generally left on too

TABLE 3—Range and average time milking machines were on cows for the 4 parlor types

Range in time machine is on cow	Parlor type			
	Herringbone	Walk-thru	U shape side-opening	In-line side-opening
minutes	percent	percent	percent	percent
Under 2.0	0.5	3.3	2.7	3.4
2—2.9	2.1	8.9	5.9	6.8
3—3.9	7.8	21.2	19.0	17.2
4—4.9	15.8	21.2	21.1	18.2
5—5.9	21.6	16.2	20.6	17.7
6—6.9	17.8	11.1	9.2	15.2
7—7.9	17.0	11.1	7.6	7.4
8—8.9	8.9	3.9	5.4	3.4
9—9.9	4.8	1.1	3.8	3.4
10 and over	3.6	1.6	4.3	6.8
Average minutes machines were on cows	6.34 min.	5.01 min.	5.35 min.	5.65 min.
Average herd size	66.3 cows	45.0 cows	46.5 cows	40.1 cows

The average milker—on time for all cows in all herds was 5.8 minutes per cow.

long after the milk flow had stopped. This was more serious when one man tried to handle too many milking machines.

The average milker-on time was the highest for the herringbone and the lowest for the walk-through parlor (Table 3). Some of the milking machines were on too long because there were too many extra jobs to do. In some cases, cows did not come into the parlor without delay, or feed stuck in feeders, or there was some problem with the milking machine.

There were other reasons why milking machines were kept on too long. Black rubber milking hoses, from the milking machine to the pipe-line, prevented visual observation of the milk flow in some milking parlors. An operator could not visually determine when the milk flow had stopped unless he was directly opposite the cow. One operator, using a herringbone system equipped with black rubber milk hoses and no glass collecting cup in the milking system averaged a milker-on time of 6.5 minutes per cow. Another herringbone operator using a system with clear plastic hoses plus glass collection cups, had a milker-on time of only 4.1 minutes per cow.

Fig. 4. Milking systems equipped with clear plastic hoses and glass collection cups makes it possible for operators to observe when the milk flow has ceased.

Time Cows in Parlors

The cows were in the herringbone parlors an average of 14.1 minutes, thus had sufficient time to eat their grain. For the other parlor types this average time ranged from 6.7 to 9.6 minutes.

Dalton *et al* (1953) reported that cows ate dry grain at an average

TABLE 4—Average minutes of time cows were in the parlor, and percent of time milking machines were idle, four parlor types

Parlor type	Minutes per milking	
	Cows in parlor (eating time)	Milking machine idle time
	minutes	percent
Double 5 herringbone	14.1	4.2
Double 3 walk-through	9.6	4.8
3 U side-opening	6.7	23.3
3-in-line side-opening	7.4	30.4

rate of 0.75 pounds per minute. According to this report, a cow needed 8 minutes to eat 6 pounds of grain. Undoubtedly, some cows eat at a faster rate, however, time to eat grain was limited to less than 8 minutes for the side-opening parlors (Table 4).

Idle Machine Time

Milking machines were idle less than 5 percent of the time for the double 5 herringbone and the double 3 walk-through parlors (Table 4). This idle time was 23 to 30 percent for the side-opening parlors.

Additional Operations

Some of the dairy farmers added one to several additional operations to their basic milking routine. These operations along with the time requirements per milking are as follows:

Operation	Milking time	
	Per cow	For 50 cows
	seconds	minutes
Wiping udders dry	7.5	6.3
Dipping milkers	10	8
Dipping teats	12	10
Weigh milk(*a*)	16	13
Weight and record milk(*a*)	18	15

(*a*) Using in-line pyrex weigh jars.

Two operators used in-line pyrex weigh jars suspended on an 8-inch diameter face scales. This allowed the operator to see the milk weight at any time during the milking operation. These two parlors were of the double 3 walk-through type.

RATE OF MILKING

Dairymen using the herringbone systems milked at an average rate of 737 pounds of milk per man hour while the cows averaged 33.9 pounds of milk per cow daily. The rate of milking for the other parlor types was 519 pounds per man hour. Cows in these herds averaged 33.5 pounds per cow daily or nearly the same as for the herds with the herringbone systems. Therefore, the difference in the rate of milking was not due to a difference in milk production per cow.

Distance Walked

The total distance walked during one milking depended upon the type of parlor and the labor saving equipment used. In the herringbone arrangement the udders of the five cows on a side were only 36 to 38 inches apart with a maximum walking distance of less than 13 feet from the first to the fifth cow. In both the double 3 walk-through and the single 3-in-line side-opening, the udders were 8 feet apart with a maximum of 16 feet between the first and third cow. In the 3 U side-opening, the distance was only 8 feet between any of the three udders.

The total number of feet walked in milking cows was reduced for all parlor types by using labor saving equipment. The use of a "hot wire" in the holding area reduced the walking distance by as much as 616 feet when milking 50 cows (Table 5). Almost all of the herringbone parlors were equipped with a central grain feeding panel. In the double 3 walk-through parlor a central feeding panel reduced the walking distance by 800 feet. Central feeding panels were not used in side-opening parlors.

TABLE 5—Distance walked in milking 50 cows with one man milking in the four parlor types

Type	Minimum distance using all step-saving devices	Walking distance saved for each step-saving device				Maximum distance not using step-saving devices
		Hot wire in holding pen	Central feeding panel(*a*)	Outside doors controlled at each stall(*b*)	Washing hose at each stall(*c*)	
	feet	feet	feet	feet	feet	feet
Double 5 herringbone....	1,469	231				1,700
Double 3 walk-through...	1,797	385	799			2,983
3 U side-opening ...	1,167	616		627	525	2,935
3-in-line side-opening ...	2,263	616		801	534	4,214

(*a*) Almost all of herringbone parlors and a few of the walk-through parlors are equipped with a central feeding panel. These are not applicable to the side-opening parlors.

(*b*) Doors to let cows in and out are controlled at either one or both ends of the herringbone and walk-through parlors. The location of door controls vary with the side-opening parlors.

(*c*) The individually operating side-opening parlors operate best with a hose at each stall. Group handling parlors operate best with only one hose per side.

Outside doors were usually opened and closed by operating controls at one or both ends of all herringbone and walk-through parlors studied. Installation of controls at each stall for the side-opening parlors reduced walking distance by 627 to 801 feet. Using a water hose at each stall to wash udders rather than one for each parlor reduced the number of feet walked by over 500 for the side-opening parlors.

When all of the labor-saving equipment was used for all parlor types, the total distance walked while milking 50 cows was the lowest for the 3 U side-opening parlor and the highest for the 3-in-line side-opening (Table 5). The range in total feet walked was from 1,167 to 2,263. When none of the labor-saving techniques mentioned were used, the herringbone system ranked first with the total of 1,700 feet walked. This distance was about 2,950 feet for the double 3 walk-through and 3 U side-opening parlors, and 4,214 for the 3-in-line side-opening parlor.

Two-sided Herringbone Milking Parlors

The operator's time was used more efficiently in two-sided herringbone parlors when one man did the milking. Movements were only ¼ those required for the side-opening parlors and ½ those in the walk-through. Walking distance was at a minimum, cows had more time to eat grain, and the milking machines were idle only while transferring or less than 6 percent of the total time.

The double 4 herringbone system was well adapted to farms with smaller herds, older operators and dairymen using more than the minimum basic milking routine. The range in cows milked per man hour was 35 to 45 when one operator used 4 milking machines. Some of the dairymen operating with 4 milker units expressed the belief that they could handle another unit since they were not kept busy.

The double 5 herringbone appeared to be best suited to farms where the owner operator or a capable hired milker used the basic milking routine in milking 40 or more cows per milking. The average rate of milking was 44 cows per hour for one operator. A recent herringbone study in England reported 47 cows milked per hour in a double 5 herringbone parlor as the highest milking rate in any parlor type or size (Clough, 1958). A Purdue University study indicated the double 5 as more efficient than the double 4 herringbone with

machine stripping included as part of the basic routine with a milking rate of 49 cows per hour (Morris and Vestergaard, 1958). The University of Cambridge rated the double 5 herringbone as the most efficient, with high yielding cows, milking at a rate of 42 cows per hour (Sturrock and Brayshaw, 1958).

The double 6 herringbone should be rated as either a one or a two man operation, depending on the capability of the operator doing the milking. It required a young man of exceptional milking ability to handle 6 milker units by himself. In this study only one dairyman milked up to 55 cows per hour when cows were near their peak of production. The Purdue University study indicated that by omitting machine stripping, one man could milk up to 60 cows per hour. Several farmers milking alone in double 6 herringbone parlors stated that they had too much to do. Too many milking machines resulted in leaving the milkers on the cows too long.

Two dairymen in the Michigan study appeared to have a solution to the problem of how many milker units to operate. They suggested building the milking parlor building large enough for a double 5 or double 6 herringbone but actually using only 4 stalls per side while both the farmer and the cows were becoming acquainted with the new milking procedure. These dairymen expected to add the extra stall or two and the additional milker units when herd size was increased.

The double 8 herringbone was not included in this labor requirement study. The previous report by Hoglund, Boyd and Snyder (1959) indicated that two men in the same pit, especially two hired men, generally decreased the efficiency of both men. A New Zeeland report indicated that one man could milk 70 cows per hour in a double 8 herringbone (Thatcher, 1956). Grain feeding was not a part of their routine and milk production per cow averaged considerably less than our Michigan herds.

The One-sided Herringbone

Herringbone systems with six stalls on one side and three milking machines were calculated to have a milking rate of 28 to 30 cows per hour. All milker units in the one-sided herringbones were idle 27 percent of the time while cows were being let out and in and half of the cows washed. A Purdue University study (Morris and Vestergaard, 1958) indicated the one-sided herringbones to be decidedly slower than the two-sided arrangements. The calculated

the following rates of milking: 27 cows per hour using three milking machines; 34 cows per hour using four machines; and 39 cows per hour using five milking machines. Each machine was used for two cows.

Walk-through Parlors

The double 3 walk-through parlor, was found to be nearly as efficient in milking time as the double 4 herringbone. The average milking rate was 35 cows per hour as compared to 40 for the double 4 herringbone. Some dairymen have installed this system instead of a herringbone set-up because they believed that by seeing the entire side of each cow they could better observe when cows were off feed or sick. The double 3 walk-through did allow handling cows in groups of 3 each.

The average number of cows milked per man hour in the double 2 walk-through was 24. The double 4 walk-through parlor required 2 operators and these 2 men averaged 22 cows per hour per man. Thus, the rate of milking cows per hour per man was about the same for these two parlors and certainly below the rate achieved in the double 3 walk-through.

Side-opening Parlors

The rate of milking cows in the side-opening stalls depended upon the arrangement of the stalls. The rate of milking in the U type averaged 31 and 32 cows per man per hour while for the in-line arrangements these values were 26 to 28 cows. The major difference in these 2 arrangements was the reduction in the walking distance for the U type parlors. The side-opening parlors required each cow to be handled individually and thus the rate of milking was less than for the herringbone parlors or the double 3 walk-through. (See Table 6).

SUMMARY

1. None of the dairymen in this study attained a timed milking rate per man of a cow-a-minute. Most of the herds were timed at the peak of their production and during that period the maximum milking rate recorded was 55 cows per hour. This was for one man operating 6 milking machines in a double 6 herringbone.

2. About half of the dairymen who were using the double 6 herringbone had 2 men operating the 6 milking machines at the time

TABLE 6—Cows milked per hour and per man hour in four parlor types, standard for better than average milking performance

Parlor style	Number of men milking	Number of milkers used	Number of cows milked per hour		Number of cows milked per man hour
			Average	Range	
Herringbone					
Double 4.....	1	4	40	35-45	35-45
Double 5.....	1	5	44	40-50	40-50
Double 6.....	1	6	46	42-52	42-52
Double 6.....	2	6	52	47-63	23-32
Double 8.....	2	8	75	70-80	35-40
Walk-through					
Double 2.....	1	2	24	20-30	20-30
Double 3.....	1	3	35	30-40	30-40
Double 4.....	2	4	44	40-50	20-25
Side-opening U					
3 U.....	1	3	31	25-35	25-35
4 U.....	1	4	32	25-35	25-35
5 U.....	1	5	32	25-35	25-35
Side-opening					
3 in line.....	1	3	26	20-30	20-30
4 in line.....	1	4	28	20-35	20-35
Double 3 in line...	2	6	50	40-60	20-30
Double 4 in line...	2	8	52	40-70	20-35

of this study. This reduced the maximum number of cows milked per man hour to 32. The average milking rate using 2 men in the double 6 herringbone was 26 cows per man hour.

3. The average milking rate with one operator for the double 4, double 5 and double 6 herringbone was 40, 44, and 46 cows per man hour, respectively. Thus, in the double 4 herringbone the average milking rate per machine hour was 10 cows while for the double 5 and double 6 this rate was somewhat lower.

4. The one-sided herringbone was less efficient than the two sided arrangement because the milking machines were idle for more than 25 percent of the time.

5. Most of the milking machines were on the cows longer than is usually recommended. For the 4 parlor types 45 to 70 percent of the machines were on the cows 5 minutes or longer. The higher figure is for the herringbone.

6. The total time cows were in the parlors ranged from 7 minutes in the side opening parlors to 14 minutes in the herringbone. Thus, in the herringbone or walk-through parlors the cows had more time to eat their grain.

7. The milking machines were idle about 4 percent of the time in the herringbone and about 30 percent in the side opening parlors.

8. The total distance walked in milking 50 cows was calculated to be from 50 to 150 percent more for the in-line side opening parlors than in the herringbone, depending upon the step-saving operations used. The greatest walking distance was for the 3-in-line side opening parlor.

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FEED USE ON GRAIN-LIVESTOCK FARMS IN SOUTHEASTERN MICHIGAN[1]

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THE VALUE OF THE FEED which a Michigan farmer raises or buys for his livestock is likely to equal or exceed half of his gross income. In 1957, for example, the cost of purchased feed plus the estimated value of crop production less crop income averaged $7,400 for 881 cooperators in the M.S.U. farm accounting project, while gross incomes on these farms averaged $15,500. For the Area 1 cooperators, in Southeastern Michigan, the averages were $10,600 and $17,700, respectively (Doneth, 1958). Feed is thus an important input as well as an important product on many Michigan farms.

While farmers have been making rapid progress toward more economical production of feed crops, there is little evidence of corresponding gains in the economy of feed utilization. A notable exception is to be found in specialized broiler production, where feed inputs per unit of product have been almost halved within the last 30 years or so. Egg producers have also made significant gains in their output per unit of feed during the same three decades.

But what can be said for the dairy and general livestock enterprises that predominate throughout most of southern and central Michigan? Symptomatic, perhaps, is the dearth of information about actual feed consumption rates for the various classes of livestock on farms in this area.

How closely do farmers' actual feeding rates approach the optima suggested by experimental results? How do they correspond to the "expected" consumption rates commonly used for guidance in farm planning? How important are shrinkage and other losses in accounting for total feed disappearance? These questions can be partially

[1]Edward Miller and Duane Ullrey of the department of animal husbandry, and Donald Stark of the department of agricultural economics, have reviewed a draft of this article and offered helpful suggestions. Generous assistance was also received from Louis Hall, Donald Johnson, and Wilbur Dexter, extension workers in Lenawee and Washtenaw counties. Robert McLachlan performed much of the early field work.

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answered from data supplied by a small group of southeastern Michigan farmers who are cooperating in a more general study of farming adjustment opportunities.

The Problem of Adjustments in Feeding

Feed utilization is obviously a factor of major importance in attaining satisfactory incomes on dairy and livestock farms. In Washtenaw county alone, a 10 percent saving on feed could mean as much as a half million dollar increase in net farm incomes. On the other hand, livestock expansion programs aimed at increasing labor efficiency are unlikely to contribute to higher incomes unless feed can also be used at a high level of efficiency (Wheeler, 1959). The low prices and margins that now prevail for livestock and livestock products provide special incentives for eliminating waste in the use of half the inputs of the farm business.

Under these circumstances, one might expect that farmers would be able to account closely for the use of their total feed supply. Yet, just the opposite is usually true. Farm grains are not easily weighed, or even measured, at most stages in their progress from the field to the feeding area.

The disposition of original ingredients becomes uncertain after they have been blended in varying mixtures and distributed to several classes or age groups of livestock. Ear corn is sometimes shoveled directly to hogs from a loose storage pile, or it may be "hogged down" in the field. Small grains vary substantially in weight per measured bushel. Silage and chopped or loose hay can rarely be weighed conveniently on the farm. Frequently, then, the farmer has much less accurate information about the total quantities of feed he is using than about the percentage of protein in his grain mixture.

A rapid increase in corn production during a period of fairly constant livestock numbers shifted Michigan from a deficit to a surplus position in feed grain production some 10 years ago, according to Wright's analysis (1956). The shift was especially noticeable in southern and eastern Michigan, within a broad area where feed grain production was already at a fairly high level.

A Trial Feed Balance

Computations from census data suggest that the 1954 feed supply in a county such as Washtenaw was ample for feeding all livestock at

"adequate" to "liberal" rates. Total grain production, expressed in corn equivalent, exceeded sales from farms by about 2,350,000 bushels; roughage production, including a 4½ months' allowance for pasture, exceeded sales by 176,000 tons of hay equivalent (Table 1). Feed inputs at "adequate" rates, as computed in Table 2, totaled 1,814,000 bushels of corn equivalent, 14,107 tons of other concentrates, and 172,000 tons of hay equivalent. Purchases of livestock feeds, as reported by the census, totaled $1,870,000, an amount sufficient to buy all the "other concentrates," plus some additional grain or roughage.

If Crop Reporting Service data on swine numbers are accepted instead of the census count, feed consumption by swine could have been considerably larger than shown in Table 2. Other factors that might account for differences between the supply estimates and the consumption estimates include (1) changes in farm inventories of feed, (2) shrinkage and other storage losses, (3) inaccurate estimates of production and sales, (4) inaccuracies in the enumeration of livestock other than swine, and (5) differences between actual feeding rates and the "adequate" rates shown in Table 2.

TABLE 1—Feed production and disappearance in Washtenaw county, 1954

Item	Produced(*a*)	Sold(*a*)	Difference
	Thousand bushels	Thousand bushels	Thousand bushels
Grains			
Corn	2,867	1,218	1,650
Oats	1,367	291	1,075
Barley	53	13	40
Mixed grain	30	10	19
Wheat	767	633	115
Total, in corn equivalent			2,350
	Thousand tons	Thousand tons	Thousand tons
Roughages			
Corn silage	71	.....	71
Hay	92	6	86
Subtotal, in hay equivalent			110
Pasture, in hay equivalent(*b*)			66
Total, in hay equivalent			176

(*a*) Data from 1954 Census of Agriculture.
(*b*) Sixty percent of the preceding subtotal.

TABLE 2—Expected feed inputs computed at "adequate" rates for Washtenaw county livestock, 1954

Kind of livestock	Number of head(a)	Grains (corn equiv.)		Other conc.		Roughages (hay eq.)	
		Per head	Total	Per head	Total	Per head	Total
	Thousands	Bushels	Thousand bushels	Pounds	Tons	Tons	Thousand tons
On Hand							
Milk cows	17	35	595	500	4,250	5.5	94
Other cows	2	2	4	...	.....	5	10
Heifers and heifer calves	13	7	91	80	520	2.3	30
Sheep, 1 yr. and over	33	1	33	...	.....	0.5	17
Chickens, 4 mo. and over	245	1	245	30	3,675	...	..
Horses and mules	1	30	30	...	.....	5	5
Sows (farrowed)	6	25	150	400	1,200	...	..
Sold Annually							
Fed cattle	6	40	240	400	1,200	2	12
Sheep and lambs	35	1	35	15	262	0.1	4
Broilers	50	..	...	10	250	...	..
Other chickens	116	0.1	12	20	1,160	...	..
Hogs	34	11	373	90	1,530	...	..
Turkeys	6	1	6	20	60	...	..
Total feed inputs			1,814		14,107		172

(a) Data from the 1954 Census of Agriculture. The number of fed cattle sold was separated from other cattle sales by deducting estimated sales of cull cows. The Crop Reporting Service reported 8,400 sows farrowed and a State-wide average of 7 pigs saved per sow, suggesting considerably larger total feed inputs for swine than computed above.

Actual Feeding Rates on Sample Farms

Verified estimates of actual feeding rates for a small group of southeastern Michigan farms are presented in Table 3. These data were collected primarily to provide background for a series of case studies of farming adjustment possibilities. During the summer of 1957, some 40 farm operators were asked to cooperate by mailing monthly reports on livestock numbers, feeding rates for each class of livestock, feed inventories, feed mixing practices, and livestock sales.

Opening inventories of feed grains were measured, and subsequent visits occasionally provided opportunities to re-measure feed in corn cribs, grain bins, or haymows. Despite good intentions, not all of the cooperators provided complete records for an entire year, and the summary tables are based on records from only 17 farms. In each of these cases, however, reported feed inputs have been cross-checked with inventory, production, and purchase data, and adjustments have been made to improve the accuraey of the original estimates.

Each of the 40 original cooperators kept one or more classes of livestock including swine, beef cattle, or sheep, and each was chosen

randomly from certain strata found in a preliminary survey of about 500 Washtenaw and Lenawee county farms with annual sales of $2,500 or more. Most of the Washtenaw county farms were rather highly diversified, with combinations of four or five kinds of livestock appearing in several instances.

With one to three age classes for each kind of livestock, individual producers reported on feed consumption by as many as 10 livestock groups, with a corresponding variety in the kinds of feeds and feed ingredients. Several of the Lenawee county cooperators, on the other hand, were specialized steer feeders.

Steers were fed nearly eight pounds of concentrates per pound of gain (Table 3). Even this figure understates the actual feeding rate slightly, as it includes an allowance of only 56 pounds per bushel for the grain fed in ground ear corn. Only five lots of steers received any silage, and only one lot received as much as 2 tons per head.

Some of the steers were bought at light weights and fed for 250 to 300 days, while others were bought at average weights of around

TABLE 3—Feeding rates and liveweight gains per head for meat animals on sample farms, 1957-58

Item	Steers	Hogs	Lambs
Number of Records	10	14	6
Concentrates Fed	Bushels	Bushels	Bushels
Corn	48.6	11.4	3.9
	Pounds	Pounds	Pounds
Protein supplement	277	59	3
Other concentrates	99	362	42
Total concentrates(*a*)	3,100	1,040	260
Harvested Roughages Fed			
Hay	1,240	....	300
Silage	1,000	....	....
Total (hay equivalent)	1,600	....	300
Average Liveweights			
Final	1,012	217	88
Starting	608	45	(*b*)
Gain	404	172	(*b*)

(*a*) Includes corn figured at 56 pounds per bushel.
(*b*) The lambs probably averaged between 50 and 60 pounds per head when the feeding period began in the fall, after the pasture season.

700 pounds and fed for shorter periods. The feeding periods averaged 228 days, with a daily average gain of 1.7 pounds.

Total feed consumption appeared liberal for the 404-pound average gain. For a somewhat similar steer feeding program, Smith's analysis (1955) assumed use of 41.4 bushels of corn, 420 pounds of protein supplement, and 1,560 pounds of hay, to feed 450 pound calves to 1,000-pound marketing weights. On this basis, the average feed inputs per pound of gain would include 5 pounds of concentrates plus 3 pounds of hay, a level of efficiency that has been equalled or exceeded, especially with the use of stilbestrol, in experiments at Michigan State University (Animal Husbandry Department).

Hog feeders used about 6 pounds of total concentrates per pound of gain. Average feed inputs per hog can be expressed as about 60 pounds of protein supplement, plus 18 bushels of corn equivalent. This grain input may be regarded as extravagant, especially in view of research which suggests that comparable gains can be made with as few as 8.5 bushels of corn equivalent plus 50 pounds of protein supplement (Heady, Woodworth, Catron, and Ashton, 1954). Under average-to-good performance in dry lot, a 225-pound hog could be fed from weaning on about 10 bushels of corn equivalent plus 102 pounds of supplement, according to Hoefer, Moxley, and Rust (1955).

The lowest feed inputs were for two droves of hogs that consumed about 10 bushels of corn equivalent and 80 pounds of protein supplement. Daily gains per hog ranged from slightly less than a pound to 1.4 pounds. On the average, there was little difference between the feed consumption rate for spring and fall pigs.

The six lamb flocks also seem to have consumed grain rather freely in relation to the gains made, but actual weights at the end of the pasture season when feeding began were not available. Feeding rates were rather uniform among the six flocks.

Milk cows consumed about 3,700 pounds of concentrates and 6 1 tons of total hay equivalent (Table 4). Roughage consumption during the barn feeding period was used to estimate roughage consumption per cow month during the pasture season. Annual production per cow averaged almost 9,000 pounds of milk testing 3.8 percent butterfat. The dairymen were thus feeding about 1 pound of concentrates for each 2.4 pounds of milk produced. Three dairymen fed more than 1 pound of concentrates for each 2 pounds of milk, and one of them discovered at the end of the year that he had fed a pound of grain for each 1.2 pounds of milk.

TABLE 4—Annual feeding rates per head for dairy and breeding stock on sample farms, 1957-58

Kind of feed	Milk cows	Dairy young stock	Ewes	Sows and gilts
Number of Records	9	8	6	6
Concentrates Fed	Pounds	Pounds	Pounds	Pounds
Farm grains	3,200	770	150	2,130
Other concentrates	520	150	30	410
Total	3,720	920	180	2,540
Roughages Fed	Tons	Tons	Tons	Tons
Hay	3.1	1.1	0.3	...
Silage	3.1	0.6	...	...
Sub-total (hay equivalent)	4.1	1.3	0.3	...
Pasture (est. hay equivalent)	2.0	0.6	0.3	...
Total (hay equivalent)	6.1	1.9	0.6	...

Concentrate feeding for the ewe flocks ranged from 54 pounds per head to 275 pounds per head. The lamb crop averaged just about 100 percent.

Sows and gilts were managed on the two-litter system, but the actual number of litters was slightly less than two per sow. Consumption rates shown for the sows and gilts include feed consumed by their pigs before weaning.

Shrinkage and Other Losses

The shrinkage of corn in farm cribs appeared to range up to 20 percent or more in several cases where observations could be made. Losses to rats and mice were probably appreciable in several cases. Small amounts of moldy feed were discarded in one or two cases, and one report of substantial loss from spillage was received.

Waste was also observed around hog and poultry feeders. Such losses must be considered in any attempt to make an accurate accounting of feed disposition. Another type of "loss" occurred when the feed production calculated from estimated yields per acre failed to materialize in farm storages. Variations in the test weights of oats added to the problem of estimating the actual disappearance of this feed grain.

Opportunities for more economical use of feed

In hog feeding particularly, these results suggest wide opportunity for more effective use of farm feed supplies. In other livestock feeding, there are also substantial gaps between farm practice and the results that have been achieved under experimental conditions. These results correspond with the conclusion by Allen (1950) that a sample of 100 farm account cooperators fed 36 percent more concentrates than suggested by feed budget planning data. Further analyses on the sample farms will explore specific adjustments in feed use.

In seeking ways of using feed supplies more effectively, farmers may need to reconsider the quantity and quality of the proteins fed at various stages of growth or production. They may also need to recall the importance of water as a complement to feed in hog production. Disease control will provide the key to improved feed efficiency in a number of cases. Possibilities for eliminating physical waste at feeders and storages were observed on several of the study farms. Farmers with several kinds of livestock may find that increased specialization will offer an indirect means of improving feed efficiency, through permitting more careful observation and control of feed use.

The present results suggest strongly that grain-livestock farmers throughout Michigan would do well to take a closer look at their use of feed — a resource that represents as much as half of all inputs on many farms. In Washtenaw county alone, a 10 percent saving of feed could mean a half million dollar increase in net farm income.

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DISPERSIBILITY AND FLAVOR OF DRY MILK: EFFECT OF RECONSTITUTION IN 50 TO 100°C WATER

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INTRODUCTION

SELECTION OF DRY MILK for institutional food preparation requires an evaluation of the product for flavor, dispersibility, and cost. For the production of high quality foods, flavor is always the primary consideration. Because the types of dry milk which can be reconstituted most easily are also usually more expensive than the less soluble types, the institution buyer must next decide whether cost or dispersibility is more important.

Processing of dry milk may cause some structural changes in the lactose and milk proteins. The extent of these changes determines the dispersibility of the dry milk in water when it is reconstituted.

Although the institution purchaser cannot control the effect of the processing method on the dispersibility of dry milk, he can select the reconstitution method and the temperature of the water he will use. If dry milk can be combined satisfactorily with water at temperatures higher than lukewarm, which is most widely recommended, he can reduce preparation time for many products.

The purpose of this investigation was to determine, with a controlled method of reconstitution, the effect of water temperature on the dispersibility and flavor of dry milk. The selected brands were typical of the types of dry milk available to the institutional consumer.

METHOD OF PROCEDURE

Dry milk samples used in this study represent different methods of processing. The standardized procedure which was developed was based on a method which could be adapted to quantity use.

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Materials

The selected samples of whole and nonfat dry milk were reconstituted in tap water to determine the effect of water temperature on dispersibility and flavor.

Dry milk

Four types of dry milk were studied: nonfat instant fluffy, nonfat instant fine, nonfat regular spray-dried, and whole (Fig. 1). Twelve brands of dry milk were purchased in sufficient quantities for the completion of the study. These included two brands of the nonfat instant fluffy type, four brands of the nonfat instant fine type, three brands of the nonfat regular spray-dried type, and three brands of the whole type. The dry milk samples were coded as follows:

A: Nonfat instant fine
B: Nonfat regular spray-dried

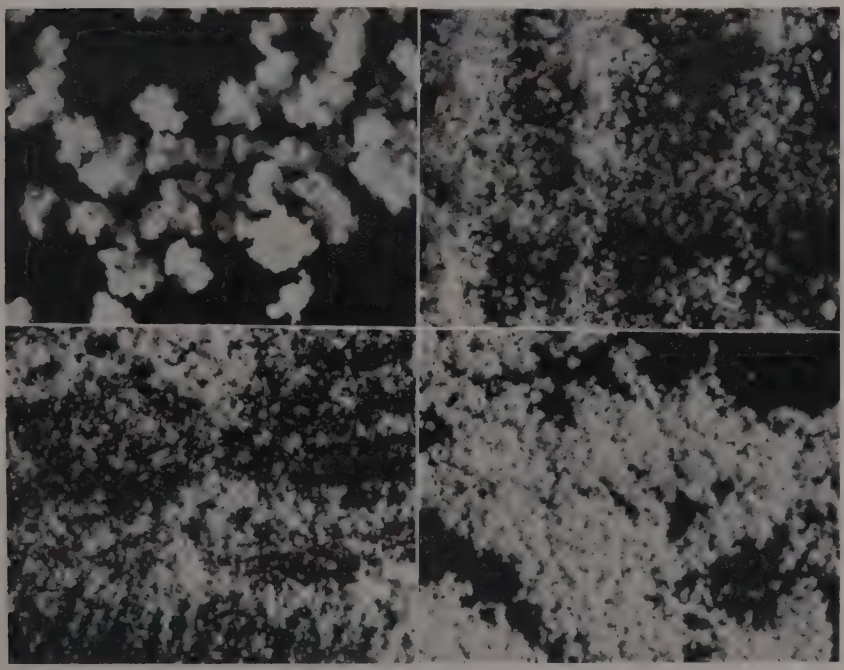

Fig. 1. Representative samples of the four types of dry milk granules which were studied (each sample magnified 10 x). Upper left, nonfat instant fluffy; upper right, nonfat instant fine; lower left, nonfat regular spray-dried; lower left, whole.

C: Nonfat regular spray-dried
D: Nonfat instant fine
E: Nonfat instant fluffy
F: Nonfat instant fluffy
G: Nonfat regular spray-dried
H: Nonfat instant fine
I: Nonfat instant fine
K: Whole
L: Whole
M: Whole

Proportion of dry milk and water

The proportion of water and dry milk generally recommended by manufacturers was used to reconstitute three lots from each brand of dry milk. For each lot of nonfat dry milk 3.25 ounces (92.2 gm.) of dry solids were added to 3.75 cups (850.5 gm.) of tap water of the designated temperature. To reconstitute each sample of dry whole milk, 4.50 ounces (127.6 gm.) of dry milk were added to 850.5 gm. of water.

Ingredients were weighed on a 2-kilogram capacity torsion balance. Weighed samples of dry milk were placed on squares of waxed paper to facilitate the transfer of the dry milk to the water.

Reconstitution and Drying Procedure

The standard reconstitution procedure for the study was based on the preliminary investigations and the preferred procedure for combining dry milk and water in quantity cookery.

Preliminary Determinations

To determine the number of stirring strokes to use throughout the study, samples of each brand of dry milk were completely dispersed in 50°C water. The number of stirring strokes and the time required for complete dispersal were recorded. After comparing the data for all brands of dry milk, a standard number of stirring strokes was established for nonfat dry milk and for dry whole milk. A number was selected which would leave some undispersed solids in all samples, even the most soluble dry milk. The selected standard for nonfat dry milk was 30 strokes in 12 to 14 seconds; for dry whole milk a standard of 20 strokes in 8 to 10 seconds was established.

Reconstitution

Three samples of each brand of dry milk were reconstituted in water at each of six temperatures: 50, 60, 70, 80, 90, and 100°C. To obtain the desired temperature, boiling and cold water were mixed with a glass stirring rod in a 2-liter pyrex beaker until the designated temperature registered on a laboratory precision thermometer. The amount of water was then adjusted until the desired weight was obtained.

For the series which required boiling water, the beaker of boiling water was covered with aluminum foil immediately after being weighed. The covered beaker was then placed on a speed-heat electric unit to bring the water back to the boiling point with minimum evaporation loss. As soon as the water resumed boiling, the beaker was removed from the unit, the cover quickly lifted, and the dry milk added to the water.

Each sample of dry milk was sprinkled on 850.5 grams of water at the specified temperature in a 2-liter pyrex beaker and stirred with a 12-inch aluminum french whip. The dry milk and water mixture was then poured through a wire strainer, 30 mesh per linear inch, into a 1-liter graduated cylinder of known weight.

After the residue had drained 5 minutes, the strainer was removed. The weight and measurement of the liquid milk in the graduated cylinder were recorded. The liquid milk was then poured into plastic storage containers which were tightly covered and refrigerated at 40°F until time for judging.

Drying

The dry milk residue was transferred from the strainer to a weighed 4-inch watch glass. The watch glass containing the dry milk solids was weighed to the nearest 0.01 gram on a Cenco triple-beam balance. The dry milk residue was then dried in a standard precision Freas gravity convection oven at 60°C until the samples reached constant weight. The drying oven capacity limited the number of samples which were reconstituted each period to 36.

Judging Flavor

After cooling 24 hours in the refrigerator, the 36 reconstituted dry milk samples were scored for flavor by three judges. The judges evaluated the flavor of each sample as satisfactory or unsatisfactory, with minus and plus signs to indicate degrees of acceptability.

After the original evaluations were discussed with a statistician, they were assigned numerical scores of 1 to 7 for analysis. The numerical values were then paired with descriptive terms:

7 — Like very much
6 — Like moderately
5 — Like slightly
4 — Neither like nor dislike
3 — Dislike slightly
2 — Dislike moderately
1 — Dislike very much

Evaluating Data

The amount of undissolved solids for each replication was determined by deducting the weight of the watch glass from the final weight of the dried residue in the watch glass. The residue weights were averaged for the three replications of each brand of dry milk in each temperature of water. The average percentage of undispersed dry milk solids per quart of fluid milk was determined by dividing the mean figure by the original weight of the dry milk used in the reconstitution.

The flavor scores of the three judges for three replications of each brand were averaged. The mean scores were compared to determine the relative acceptability of the samples.

RESULTS AND DISCUSSION

Both dispersibility and flavor varied considerably among the four types of dry milk and among the brands of the same type (Table 1). The relationship between dispersibility and flavor was also inconsistent.

Dispersibility

Differences noted among types and among brands of the same type indicate that the main criterion for selecting a product with high dispersibility characteristics is actual reconstitution.

Examination of the dispersibility data indicated that the average percentages of undispersed solids from each brand of dry milk formed a sufficient basis for comparison. Therefore, the sources of variance were not analyzed statistically.

*TABLE 1—Percentage of undispersed solids from one quart of reconstituted dry milk**

Type	Brand	Water temperature in °C					
		50	60	70	80	90	100
Nonfat instant fluffy	E	.07	.02	.09	.17	.83	3.08
	F	.08	.03	.03	.09	.07	.25
Nonfat instant fine	A	.09	.24	.25	.60	2.04	2.59
	D	.25	.60	.26	1.26	.69	1.05
	H	.14	.18	.14	.13	.37	.72
	I	.14	.34	.94	2.60	9.16	11.16
Nonfat regular spray-dried	B	4.44	6.57	15.97	24.09	23.14	38.21
	C	.25	.60	.26	1.25	3.98	17.48
	G	1.55	2.34	4.58	8.15	19.46	26.87
Whole	K	3.55	7.05	17.37	17.62	13.91	11.63
	L	.06	.13	.12	.77	1.82	1.46
	M	3.15	5.90	6.74	9.78	11.83	12.72

*Each figure represents the average of three replications.

The amount of liquid remaining after reconstitution was inversely related to the amount of undispersed solids. Because of the obvious relationship, the data for the liquid were not further considered.

Nonfat instant fluffy dry milk

Less than 1.0 percent of undispersed solids remained from all but one reconstitution of nonfat instant fluffy dry milk (Fig. 2). The two brands of nonfat instant fluffy dry milk, Brands *E* and *F*, were among the three most dispersible brands of dry milk in 50 through 80°C water.

In 70, 80, 90, and 100°C water, Brand *F* was the most dispersible of all dry milk tested in this study (Table 1). Even when this brand was mixed in boiling water, only 0.25 percent remained undispersed. Brand *E* ranked sixth place when dispersed in 100°C water; slightly over 3.0 percent solids remained.

Nonfat instant fine dry milk

All four brands of nonfat instant fine dry milk left less than 1.0 percent of undispersed solids in 50, 60, and 70°C water (Fig. 2). The dispersibility of the four brands varied markedly in 80, 90, and 100°C water.

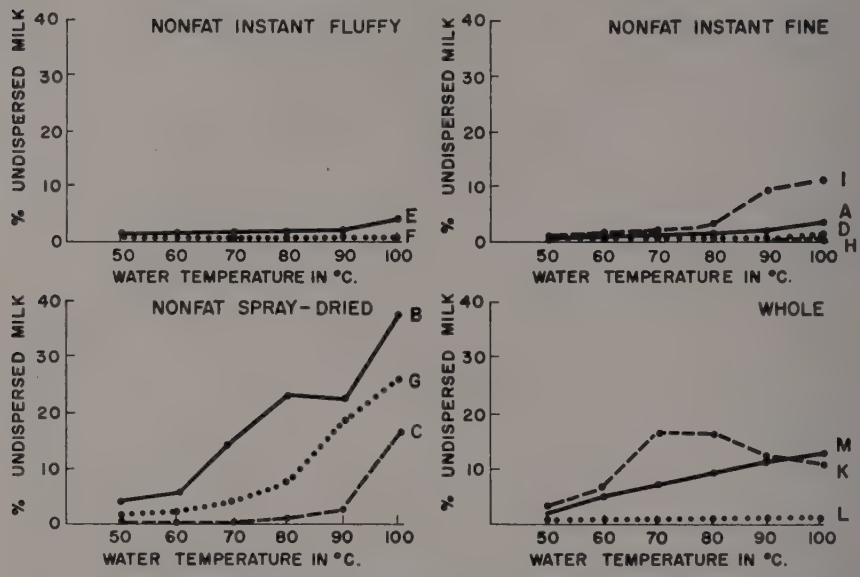

Fig. 2. The effect of water temperature on the dispersibility of various brands of four types of dry milk granules (three replications of each brand).

Brand *H* dispersed more completely than the other three brands of nonfat instant fine dry milk. Less than 1.0 percent of solids remained after reconstitution in all temperatures of water. Of all brands of dry milk tested in this study, Brand *H* ranked second in dispersibility in 80, 90, and 100°C water (Table 1).

The dispersibility pattern for Brand *D* fluctuated from the pattern followed by most brands of dry milk in this study (Table 1). The amount of undispersed solids which remained after reconstitution was lower in 70°C water than in 60°C water; lower in 90°C water than in 80°C water; and highest in 80°C water; Brand *D* ranked seventh place in 80°C water and third place in 90 and 100°C water.

Brand *A* left less than 1.0 percent of undispersed dry milk solids in 50, 60, 70, and 80°C water. The amount of undispersed dry milk solids increased from 0.60 percent in 80°C water to 2.04 and 2.59 percent in 90 and 100°C water, respectively. Rankwise, Brand *A* was fourth place in 50°C water and fifth place in 100°C water (Table 1).

Brand *I* dispersed less than the other three brands of nonfat instant fine dry milk in all temperatures of water above 50°C. In 60 through 90°C water Brand *I* maintained the rank of eight; it ranked seventh in 100°C water (Table 1).

Nonfat regular spray-dried milk

The dispersibility of the three brands of nonfat regular spray-dried milk varied considerably (Fig. 2). In 50°C water the amount of undispersed solids varied from 0.25 to 4.44 percent; in 100°C water the solids ranged from 17.48 to 38.21 percent.

Brand *C* left less than 1.0 percent undispersed solids in 50, 60, and 70°C water (Table 1). The amount of solids that remained from Brand *C* regular spray-dried and Brand *D* nonfat instant fine dry milk was almost identical in 50 through 70°C water. In 90 and 100°C water, however, Brand *C* left 3.98 and 17.48 percent undispersed solids; Brand *D* left 0.69 and 1.05 percent undispersed solids.

Undispersed solids from reconstitutions of Brand *G* ranged from 1.55 to 26.87 percent. Brand *G* maintained the rank of nine in 50 through 80°C water and dropped to eleventh place in 90 and 100°C water.

Brand *B* dispersed the poorest of all brands of dry milk tested in 50, 80, 90, and 100°C water, and ranked eleventh—or next to lowest—in 60 and 70°C water. The amount of undispersed solids ranged from 4.44 to 38.21 percent.

Dry whole milk

The dispersibility pattern for two of the three brands of dry whole milk differed from most brands of dry milk used in this study (Fig. 2). The greatest amount of undispersed solids from Brand *K* was in 80°C water; from Brand *L* in 90°C water. Brand *M* dry whole milk and most brands of nonfat dry milk left the highest percentage of undispersed solids in boiling water (Table 1). Brands *K* and *M* crystals resembled the nonfat regular spray-dried milk granules which were soft and powdery to touch. Brand *L* crystals, however, were grainy.

Although Brand *L* dry whole milk was not labeled instant, it dispersed as easily as some brands of nonfat instant dry milk. Less than 1.0 percent of undispersed solids remained in 50 through 80°C water and only 1.46 percent remained in 100°C water (Table 1). Brand *L* dispersibility ranged from first place in 50°C water to fifth place in 80 and 90°C water.

Both Brands *K* and *M* left over 3.0 percent undispersed solids in 50°C water and over 11.0 percent in 100°C water. Brands *K* and *M* dry whole milk dispersibility ranked tenth or below in 50 through 80°C water, and eighth or below in 90 and 100°C water.

Flavor

Flavor acceptance varied markedly among and within types of dry milk (Figs. 3 and 4). The mean scores for each type, except whole, indicated that as water temperature was increased, flavor acceptance tended to decrease. Scores for the individual brands of dry milk, however, did not always follow the same pattern.

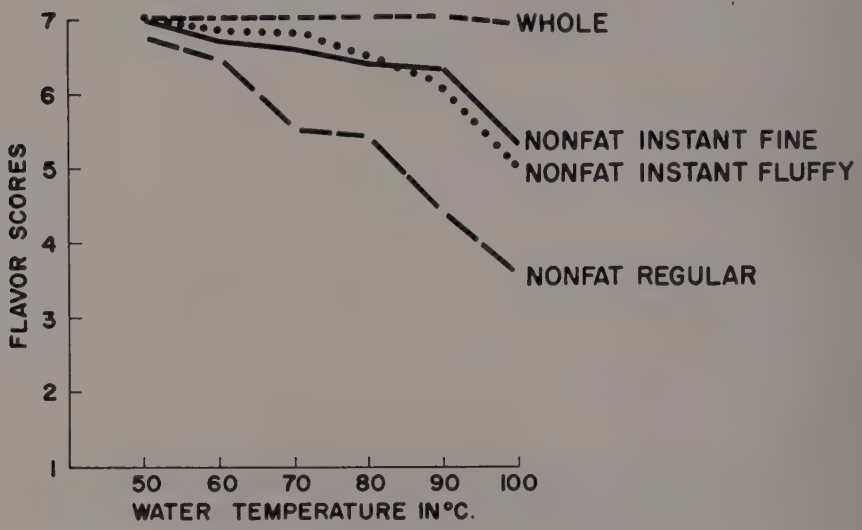

Fig. 3. The effect of water temperature on the flavor of four types of dry milk. Each type represents the average of data collected from all brands of that type.

Types of dry milk

The two brands of nonfat instant dry milk of the fluffy type received scores within 0.3 of each other, regardless of water temperature. Scores for both decreased gradually from "like very much" in 50°C water to "like moderately" in 90°C water. Flavor scores dropped more than one point to "like slightly" when these brands were reconstituted in boiling water.

The average scores for nonfat regular spray-dried milk were always lower than the other types of dry milk. Nonfat regular spray-dried milk reconstituted in 50 and 60°C water ranked within 0.5 point of the highest scored milk. As water temperature was increased beyond 60°C, however, the flavor scores fell at least one point below

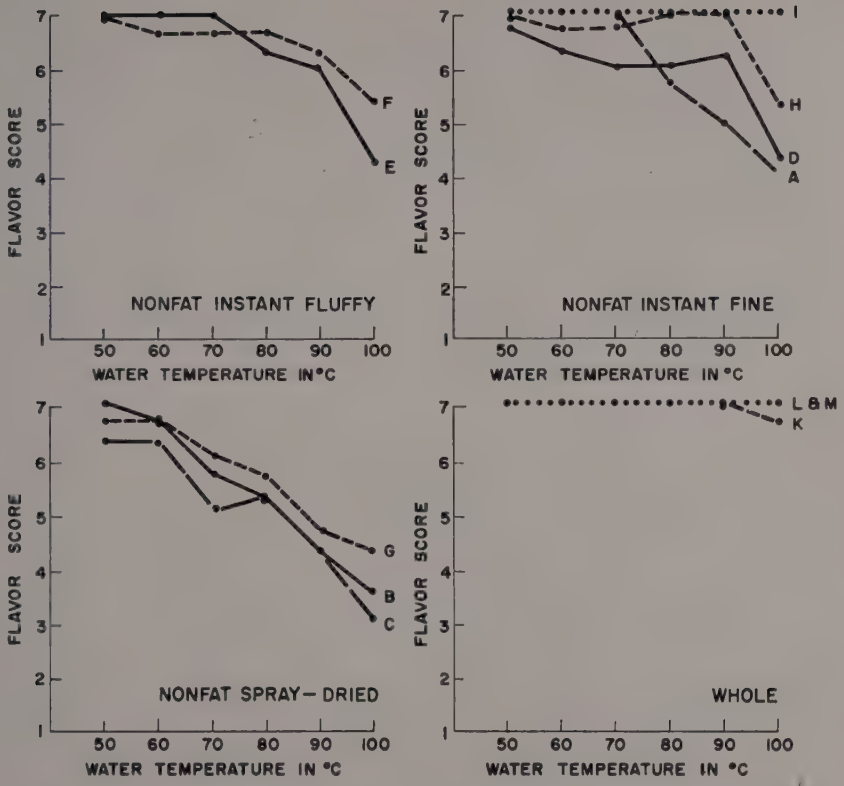

Fig. 4. The effect of water temperature on the flavor of various brands of four types of dry milk granules (three replications of each brand).

the other types and reached the "dislike slightly" point for nonfat regular spray-dried milk reconstituted in 100°C water.

Dry whole milk rated the highest possible score when reconstituted in water from 50 to 90°C. Acceptance dropped less than 0.1 point even when boiling water was used for reconstitution. Thus, dry whole milk consistently outranked the other types of dry milk in flavor throughout this study.

Brands of dry milk

Each flavor score discussed previously represents an average of two or more brands. Individual brands sometimes received scores much higher or lower than the average score for that type of dry milk.

Nonfat instant fluffy. Flavor scores for the two brands of nonfat instant fluffy dry milk varied considerably (Fig. 4). Brand E received a score of 7, the highest possible score, when reconstituted in 50, 60, and 70°C water and then dropped below Brand *F* at the higher temperatures. The flavor score for Brand *E* reconstituted in 100°C water dropped to 4.3 or almost to "neither like nor dislike". The markdown was attributed to sweetness.

Brand *F* was scored 6.7 or above until the dry milk was reconstituted in 90 and 100°C water. The judges noted an off-flavor in Brand *F* milk when it was reconstituted in boiling water and scored it down to 5.3 or "like slightly".

Nonfat instant fine. Flavor scores for the four brands of nonfat instant fine dry milk show very little consistency (Fig. 4). Brand *I*, the highest scored nonfat dry milk in this study, maintained the highest possible flavor score at all temperature levels. Brand *I* and Brand *A* shared the top rating when dispersed in 50, 60, and 70°C water. Scores for Brand *A* dry milk dispersed in 80, 90, and 100°C water dropped below the other brands, finally reaching a score of "neither like nor dislike". Reasons for the low score included cooked flavor, sweetness, and chalkiness.

Brand *H* flavor scores stayed within 0.3 point of the top position except when it was dissolved in 100°C water, where the score dropped abruptly from a score of 7 to 5.3 or "like slightly". Judges commented that the milk tasted sweet and chalky.

Brand *D* received the lowest flavor scores of the nonfat fine dry milk reconstituted in 50, 60, and 70°C water, and rose above Brand *A* for reconstitutions in 80, 90, and 100°C water. The flavor score for Brand *D* reconstituted in 100°C water was just slightly above "neither like nor dislike". This score was attributed to sweetness.

Nonfat regular spray-dried. The scores for the three brands of nonfat regular spray-dried milk followed a downward trend, gradually dropping three to four points as the water temperature was increased from 50 to 100°C (Fig. 4). Brand *G* received the highest score for nonfat regular spray-dried milk reconstituted in all temperatures of water except 50°C where it was ranked slightly under Brand *B*. Scores for Brand *G* dropped gradually from 6.7 to 4.3, with sweetness, chalkiness, and weakness given as objectionable characteristics.

Brand *B* scores fell slightly below *G* except when reconstituted in

50 and 60°C water. Criticisms, consisting of weakness, wateriness, and chalkiness, lowered the score to "dislike slightly" for reconstitutions in 100°C water.

Flavor of Brand *C* was generally scored lower than the other two brands of nonfat regular spray-dried milk. However, it tied with Brand *B* at 80 and 90°C. Comments indicated that Brand *C* received a score of "dislike slightly" because of sweet, chalky, and cooked flavors.

Whole. All three brands of dry whole milk maintained the highest possible flavor scores except Brank *K* which was reconstituted in 100°C water; the score dropped from 7.0 to 6.3 (Fig. 4). This drop resulted from the detection of a slight off-flavor by one judge.

Relation between Dispersibility and Flavor

Although dry milk samples with low dispersibility might be expected to have less flavor and body than those which disperse completely when reconstituted, the data of this study did not support such a conclusion. No consistent dispersibility-flavor relationship was evident within brands of the same type of dry milk. Figs. 2 and 3 reveal a slight tendency toward decreased flavor scores as nonfat fluffy dry milk dispersibility decreased. In contrast, one of the least dispersible brands of nonfat instant fine dry milk always rated the highest possible flavor scores; the most dispersible brand received low flavor scores. Among the brands of nonfat regular spray-dried milk the most dispersible brand was the least preferred. In the dry whole milk samples, dispersibility and flavor apparently were not related.

SUMMARY

The dispersibility and flavor of 12 brands of dry milk, reconstituted in 50 to 100°C water, were compared. The 12 brands included four types: nonfat instant fluffy, nonfat instant fine, nonfat regular spray-dried, and dry whole milk.

A standardized procedure for reconstitution, which permitted some undispersed dry milk to remain in even the most dispersible samples, was established in preliminary testing. Three 1-quart samples of each brand were reconstituted and strained. The reconstituted liquid portion was refrigerated and judged for flavor. The undispersed solids which remained in the strainer were dried to constant weight for

determining the percentage of undispersed dry milk in each sample.

Dry milk dispersibility generally decreased as water temperature increased. A few brands, however, varied from the general dispersion pattern. The variation in the extent of dispersion of brands of dry milk within and among types eliminated the practicality of comparing average figures for the types. One brand of nonfat instant fluffy and one brand of nonfat instant fine dry milk left less than 1.0 percent undispersed solids in all temperatures of water. The least dispersible dry milk in both 50 and 100°C water was a brand of nonfat regular spray-dried which left 4.44 percent undissolved solids in 50°C water and 38.21 percent in 100°C water.

Dry milk flavor scores varied considerably among types and brands. The fluctuations were greater among brands of nonfat dry milk than among brands of dry whole milk. All brands of both types of nonfat instant dry milk reconstituted in 50, 60, and 70°C water and all brands of nonfat spray-dried milk reconstituted in 50 and 60°C water were scored 6.0 or above. As water temperature was increased above 70°C, the flavor scores for the various brands of nonfat instant dry milk did not follow the same pattern. For samples of nonfat dry milk reconstituted in 100°C water, scores ranged from 3.0 to 7.0, the highest possible score. Dry whole milk received scores of 7.0 for all reconstitutions except one brand which was scored 6.7 when reconstituted in 100°C water.

The most dispersible brands of dry milk were not always judged highest flavorwise; nor did the least dispersible brands of dry milk consistently receive the highest flavor scores.

JOURNAL ARTICLE ABSTRACTS

Controlled Temperature Swine Housing—A Progress Report

Kazarian, E. A.; J. S. Boyd and S. M. Ruffin

Ag. Engr. 1:45-47. 1958. (Journal Article 1951 from the Michigan Agricultural Experiment Station)

During the summer of 1955, a hog feeding trial was conducted to determine the effect of improved climatic environment on the growth rate and feed efficiency of market hogs.

Six random selected hogs averaging 35 pounds were placed in each of three portable houses. One house contained double pane windows and was insulated and ventilated. The second house was similar to the first house with the exception of air conditioning. The control house of conventional design was provided with a concrete feed lot.

Temperatures in the three houses and the outside temperature were recorded hourly. Weight of the hogs and feed consumption were recorded every two weeks.

The hogs in the air conditioned and double pane houses made more rapid gains than the hogs in the conventional house. There was little difference in the gain of the hogs in the air conditioned house as compared to the double pane house.

Factors that Affect the Distribution of Water from a Medium Pressure Rotary Irrigation Sprinkler

Bilanski, W. K. and E. H. Kidder

Ag. Engr. 1:19-23, 28. 1958. (Journal Article 2015 from the Michigan Agricultural Experiment Station)

This study was conducted indoors on a single medium pressure rotary irrigation sprinkler. It was a popular size with irrigators and was a practical size for a laboratory study of distribution patterns. Typical irrigation patterns are triangular in shape in which the maximum amount of fall-out is near the sprinkler and gradually tapers out to 0 at the maximum trajectory distance. A second type of desired pattern is that in which the amount of fall-out is nearly uniform for the greater portion of the radius then decreases gradually for the remainder of the trajectory distance. It was because many sprinklers presently available did not give either of the above distribution patterns that it was decided to make a study of the factors that affected the distribution pattern. The following factors were investigated and evaluated: oscillating arm, operating pressure, orifice diameter, length of the cylindrical portion of the nozzle, angle of taper in the sprinkler nozzle, angle of inclination of the nozzle, rate of rotation of the sprinkler, roughness in the cylinder part of the sprinkler nozzle, length of the tube between the body of the sprinkler and the nozzle, non-circular shaped orifices in the sprinkler nozzle, the use of cylindrical discharge tubes in the place of nozzles. It was found that the oscillating arm accentuated the fall-out of water near the sprinkler. The use of non-circular orifices of short cylindrical tube length in place of conventional sprinkler nozzles resulted in a more desirable pattern of water distribution.

The most desirable patterns were obtained from tube lengths ranging from

2 to 4 diameters. Turbulence, distribution of velocities and the amount of secondary motion affected dispersion of the jet of water as it emerges from the sprinkler nozzle.

The Effect of Prolonged Leaching and of Successive Generations of Plants on the Solubility of Iron and Managanese in Glassy Frit

WILDON, C. E.

Proc. Am. Soc. for Hort. Sci. 72:443-449. 1958. (Journal Article 2020 from the Michigan Agricultural Experiment Station)

Experiments with various crops in hydroponic culture were arranged to determine solubility of iron and manganese in glassy frit.

In the course of usage of the frits, solubility of iron has decreased materially, while solubility of manganese continued very high.

The effect of pH on solubility of iron shows a tendency toward less solubility as H - ion concentration decreases. The solubility of manganese is greatly decreased as H - ion concentration decreases.

With usage manganese in the frit is exhausted more rapidly than is the ion.

Leaching of Nutrients from Plant Foliage and Determined by Radio-Isotopes

TUKEY, H. B.; S. H. WITTWER AND H. B. TUKEY, JR.

Radio-isotopes in Scientific Res. Vol. IV, pages 304-322. (Proc. 1st UNESCO Int. Conf., Paris, 1957) Pergamon Press: London, N.Y. and Paris 1958. (Journal Article 2092 from the Michigan Agricultural Experiment Station)

Loss of root-absorbed nutrients from plant foliage by leaching with aqueous solutions has been demonstrated using radio-isotopes. Seedlings of bean and squash were grown in nutrient culture solutions containing various varioactive isotopes. The leaves of the plants were leached by (a) soaking in aqueous solutions, (b) misting with a water spray. The leachate was concentrated and the radioactivity determined.

Nutrients were classified according to their ease of leaching from foliage.
Easily leached—Na^{22}, Mn^{54}.
Moderately leached—Ca^{45}, Mg^{28}, S^{35}, K^{42}, Sr^{90}–Y^{90}.
Leached with difficulty—$Fe^{55\text{-}59}$ Zn^{65}, P^{32}, Cl^{36}.

Losses were greater from older leaves than from very young leaves. The type and variety of plant influenced losses. Losses increased as the length of the leaching period increased. As nutrients were leached, they were apparently replaced from other plant parts. Nutrient deficient plants lost more nutrients than did healthy plants. Carbohydrates were also leached from leaves and the loss paralleled the light intensity. Loss of carbohydrates from strawberry fruits increased with the maturity of the fruit, but losses of Sr^{90}-Y^{90} were 75 percent of the nutrient in the fruit regardless of maturity. Greenhouse plants or those protected from rainfall contained more of the leachable nutrients than did unprotected plants in the orchard.

Some Greenhouse Studies on Alfalfa with Soil Type, Soil Reaction and Borax Fertilization as Variables

BAKER, A. S. AND R. L. COOK

Agron. Jour. 51:1-4. 1959. (Journal Article 2104 from the Michigan Agricultural Experiment Station)

The amount of B extracted from soils by the 5-minute boiling procedure was poorly correlated with the level of B in plants, except in soil high in alkaline organic matter. The best test of the B supplying power of soils is a plant tissue test. Rate of equilibrium establishment seemed to be important in determining B supplying power of soil.

There was no correlation between yield or percent Ca, Mg, K, P, or protein in alfalfa and the concentration of B, when B varied between weak B deficiency and higher levels below the toxicity range. When deficiency was severe, yield responses to borax were obtained. Mg, K, P, and protein were higher in severely deficient than in healthy plants, due probably to dilution. Ca, not influenced by dilution, was lower in severely deficient than in healthy plants when Ca was in short supply.

Reactions of Ammonia in Soils

MORTLAND, M. M.

Advances in Agron. 10:325-348. 1958. (Journal Article 2143 from the Michigan Agricultural Experiment Station)

This article constitutes a review of the literature concerned with reactions of ammonia in soils. Mechanisms of reactions are discussed and the nature of chemical absorption by clays and organic matter especially. Factors affecting sorption and loss of ammonia in the soil are discussed and reviewed. Effects of ammonia on soil properties and organisms are discussed.

An Ecological Study of a Man-Made Island

SKAU, C. M. AND M. W. DAY

Amer. Midland Naturalist 61:109-123. 1959. (Journal Article 2177 from the Michigan Agricultural Experiment Station)

A study of the development of natural vegetation on an island created by dredging in the St. Marys river was conducted over a period of 23 years. The island was about 5 acres in area and rose 14 feet above water level. Successional changes have been relatively rapid and in 9 years the island was nearly 100 per cent occupied. Perennials are the dominant vegetation over most of the island now, most of the annuals having been replaced. Two tree species *Populus tremuloides* and *Populus balsamifera* have appeared and are dominant on the sites occupied. Check lists are given to indicate changes in vegetation during period of study.

Bean Interspecific Hybrid Involving *Phaeseolus coccineus* x *P. lunatus*

HONMA, SHIGEMI AND OTTO HEECKT

Proc. Am. Soc. for Hort. Sci. 72:360-364. 1958. (Journal Article 2186 from the Michigan Agricultural Experiment Station)

An interspecific hybrid was made between *Phaseolus coccineus* and *P. lunatus*. The hybrids appeared vegetatively closer to the *P. coccineus* parent. The F_1's were self-sterile, however, in the presence of insects set pods with viable seeds. Segregation for germination habit ranged from epigeal to hypogeal. Variation in the characters observed in the segregating generation suggest polygenic inheritance.

Biochemical and Physiological Studies of Wheat Seed Pigmentation

MIYAMOTO, TAKAO AND E. H. EVERSON

Agron. Jour. 50:733-734. 1958. (Journal Article 2215 from the Michigan Agricultural Experiment Station)

Experience with soft white wheat varieties in Michigan has indicated they are far more prone to sprouting in the head at maturity than are the soft red wheats. This observation has also been made in Europe. A study was made to determine the chemical nature of wheat grain pigment. It was concluded that the main pigment was phlobaphene whose precursors are catechin and catechin tannin. The possible relationship of the difference in concentration of the pigment and its precursors to differences in germination after harvest is discussed.

Protein Distribution in Fresh and Stored Shell Eggs from Hens Fed Crude Cottonseed Oil

EVANS, ROBERT JOHN; SELMA L. BANDEMER; J. A. DAVIDSON AND DORIS H. BAUER

Agr'l. and Food Chem. 7:47. 1959. (Journal Article 2216 from the Michigan Agricultural Experiment Station)

Hens fed rations containing 2.5 percent crude cottonseed oil produce eggs that develop pink whites and large salmon colored yolks after six months or more of cold storage. Protein migrates from the white to the yolk. Eggs were obtained from 11 pullets, housed in laying cages and fed a ration of constant composition containing 2.5 percent of crude cottonseed oil. Part of the eggs were analyzed fresh and part after six months of cold storage. Composition of the migrating protein was calculated from changes in protein distribution in whites and yolks of fresh and stored shell eggs determined by paper electrophoresis. Approximately 5 percent of the white protein migrated to the yolk. The migrating protein was composed of 66 percent ovalbumin, 18 percent conalbumin, and 16 percent lysozyme, compared to 64 percent ovalbumin, 18 percent conalbumin, and 4 percent lysozyme in fresh egg white proteins. No ovomucoid and ovoglobulin appeared to be in the migrating protein. Livetin migrated from the yolk to the white. The lipovitellenin band from six-month-old eggs moved almost three times as far as that from fresh eggs during electrophoresis. Part of the lipovitellin was converted to a protein that behaved similarly to lipovitellenin under the conditions of electrophoresis used.

Synthesis of 3-Indoleacetamides

Weller, Lowell E. and Harold M. Sell

Jour. of Organic Chem. 23:1776. 1958. (Journal Article 2232 from the Michigan Agricultural Experiment Station)

N-(3-Indoleacetyl)-DL-isoleucine, N-(3-Indoleacetyl)-DL-methionine, N-(3-Indoleacetyl)-L-tryptophan, N-(3-Indoleacetyl)-L-aspartic acid, N-(3-Indoleacetyl)-L-glutamic acid, N-(3-Indoleacetyl)-6-aminopurine, N-(3-Indoleacetyl)-p-aminobenzoi acid and N-(3-Indoleacetyl)-m-aminobenzoic acid were synthesized by condensing 3-indoleacetyl chloride with the appropriate amino acid.

Farm Building Wood Truss Design

Esmay, Merle and James S. Boyd

Ag. Engr. 39:400-402, 409. 1958. (Journal Article 2233 from the Michigan Agricultural Experiment Station)

Roof loading performance tests were run on a number of full scale clear-span wood trusses 24, 30, 36 and 40 ft. in width. Trusses constructed of two different types of fasteners; mainly split ring connectors and bolts, and glue and plywood gusset plates were tested.

A single slope truss design with a 24^2 foot span was also treated with ringbolt and glue-nail fasteners. This truss is designed specifically for additions to existing buildings where there is a desire for the elimination of center poles.

Inasmuch as the trusses are designed for spacing 4 foot on center as compared to the conventional farm building design with rafters two feet on center, further testing work was done on the construction of open type and solid roof decks.

The conclusions from these tests indicate that trusses designed for four foot pacing provide light, economical roof trusses which are easily fabricated and erected by builders or farmers.

Ventilation of Chipping Potatoes During the Conditioning Period

Miyamoto, T.; E. J. Wheeler and S. T. Dexter

Am. Potato Jour. 35:778-783. 1958. (Journal Article 2235 from the Michigan Agricultural Experiment Station)

Tubers of the Russet Rural variety were submitted to different relative humidities and modified atmospheres. The potatoes were placed in a storage in late September and removed on January 12 at a temperature of 40° F. to assure maximum reducing sugar content as indicated from a frying test. The tubers were placed in sealed metal containers provided with intake and outlet for ventilation. The tubers were subjected for nine weeks at 70° F. temperature to conditions of dry air, wet air, and 10 percent CO_2 ventilated, also with the same treatments poorly ventilated. At 3, 5, 7 and 9 weeks the containers were unsealed and notes made on decay of tubers and color of the chips. Decay loss totalled at end of 9 weeks for dry air ventilated 2.8 percent, wet air ventilated 100 percent and 10 percent CO_2 ventilated 53.5 percent. The same treatments poorly ventilated showed in dry air 100 percent decay in 7 weeks with 96.4 percent in 5 weeks. In wet air the tubers decayed in 3 weeks. All of the tubers decayed in atmosphere of 10 percent CO_2 in 5 weeks with 76 percent decay in 3 weeks.

The chips were scored on basis 10 points for the darkest and 1 for white. The

chip color averaged 9.50 for all potatoes at the start. In 7 weeks the following chip colors were observed: Dry air ventilated 3.05, wet air ventilated 6.10 and 10 percent CO_2 ventilated 6.80. All of the tubers in the poorly ventilated containers had decayed, consequently, no chips were available for scoring.

Vector Representation of Biologic Fields of Force

GRAFIUS, J. E. AND R. L. KIESLING

Agron. Jour. 50:757-760. 1958. (Journal Article 2236 from the Michigan Agricultural Experiment Station)

The use of the word, "force" as applied to nature is commonplace among biologists. It would be equally possible to reverse the procedure and think of a set of genotypes acting on the environment. This set was designated a vector, in which yield was chosen as the character to be measured and, when divided by the mean yield, the vector had an average length of one. The direction of the vector relative to another set was found to be $r^2 = \cos \alpha$ where α is the angle between vectors and r represents the correlation coefficient.

Using vector representation it was possible to develop planes of force as for example, mildew planes and night temperature planes. Further, it was possible to measure objectively the influence of these forces on sets of varieties and to predict the reaction of individual varieties.

The Effects of an Irradiated Wheat Diet on the Confused Flour Beetle, Granary Weevil and the Angoumois Grain Moth

HODGES, RONALD AND GORDON GUYER

Jour. of Econ. Enty. 51:674-675. 1958. (Journal Article 2240 from the Michigan Agricultural Experiment Station)

A series of experiments was undertaken to determine whether irradiated grain differed from untreated grain as a food for three grain infesting insects and whether the length of life cycle and the rate of reproduction of the insects was affected. The test insects were the confused flour beetle, the granary weevil and the Angoumois grain moth.

Results of these experiments showed that there was no apparent deleterious effect on the reproduction potential of these insects when they were reared on a wheat diet irradiated at 10,000 rep, 100,000 rep, and 1,000,000 rep. When differences did exist, an increase in reproduction was evident.

Effects of Sweetfern Rust on the Growth of Young Jack Pine in Northern Lower Michigan

GUILKEY, PAUL C.; VICTOR J. RUDOLPH AND GEORGE SHEPPARD

Jour. of Forestry 56:900-903. 1958. (Journal Article 2245 from the Michigan Agricultural Experiment Station)

Measurements of height and diameter in two 15-year old jack pine plantations in lower Michigan showed no significant differences between the growth of healthy trees and those infected with sweetfern blister rust (*Cronartium comptoniae* Arthur). All of the cankers were at or near the ground line; apparently the trees were infected in the nursery. The exposed dead wood may

serve as an entrance court for fungi that will result in loss of wood and perhaps breakage as the bole is weakened. No important loss of wood quality or usability is expected because the canker injury is confined largely to the stump region.

Specific Gravity of Different Zones Within Potato Tubers

SHARMA, M. K.; D. R. ISLEIB AND S. T. DEXTER

Am. Potato Jour. 35:784-788. 1958. (Journal Article 2249 from the Michigan Agricultural Experiment Station)

The specific gravity of three concentric zones within tubers of 19 potato varieties was determined over the two-year period, 1956-1957. In varieties of high specific gravity there were large differences in specific gravity between the tissue at the center of the tuber and the peripheral tissue. In varieties of low specific gravity this difference was comparatively small. The central portions from all varieties were uniformly low in specific gravity. Differences in specific gravity between varieties were related to differences between the corresponding exterior tissues.

An Effective Repellent for European Hare

CARDINELL, H. A.

The Jour. of Wildlife Mgmt. 22:435-436. 1958. (Journal Article 2253 from the Michigan Agricultural Experiment Station)

Through the International Cooperation Administration and the United States Department of Agriculture, the author spent two years with the Instituto Agronomico de Sul, Pelotas, Brasil. In a planting of 353 deciduous fruit trees, 175 had been seriously injured by the feeding of the European Hare. Serious trunk injury involved 62 percent of the apples, 24 percent of the plums and 66 percent of the pear trees.

The repellent (3.18 kilograms of wood-rosin dissolved in 3.8 liters of grain alcohol) effective against the cottotail in Michigan, was brushed on about half of the trees. It proved to be a complete repellent against the European Hare. The single application was nearly as effective the second winter, under open field conditions.

To orient readers, on the climate of that area, average temperature and precipitation for 56 years by seasons, is included.

Effect of Storage Conditions on the Color of Frozen Packaged Retail Beef Cuts

TOWNSEND, W. E. AND L. J. BRATZLER

Food Tech. 12:663-666. 1958. (Journal Article 2264 from the Michigan Agricultural Experiment Station)

Boneless beef rib steaks were vacuum packed in transparent wrappers and stored at 0° F. under various storage conditions. Color degradation was measured by Munsell spinning disks and spectrophotometric estimation of metmyoglobin. It was found that temperature fluctuation, exposure to light, freezing and thawing, and various colored lights effected the amount of color degradation. There was

good agreement between the two methods of color measurement. Wave lengths of light between 560$m\mu$ and 630 $m\mu$ (yellow and orange portion of the spectrum) seem to be responsible for color degradation of packaged frozen retail beef cuts.

Irradiation of Important Grain-Infesting Pests: Order of Death Curves and Survival Values for the Various Metamorphic Forms

NICHOLAS, R. C. AND D. E. WIANT

Food Tech. 13:58-62. 1959. (Journal Article 2265 from the Michigan Agricultural Experiment Station)

Twelve grain-infesting pests were treated with 1-Mev electrons at various doses to determine the lethality of the treatment to the metamorphic forms and to determine sterility effects on the adults. Order of death curves of survivors against time at near-100 percent-lethal doses, where obtained, verify the sigmoid shape of the curves; at sub-100 percent-lethal doses, plots of survivors against dose on log-normal coordinates represent the data. In general, graded resistance is exhibited within a species increasing with insect age from egg to adult; of the insect species, the three moths showed higher radiation resistance than the beetles. Pests covered by the study include: confused flour beetle, rice and granary weevils, sawtoothed grain beetle, cadelle, Angoumois grain moth, Indian-meal moth, Mediterranean flour moth, lesser grain borer, yellow mealworm, a mite, and a psocid.

Pathology of Experimental Ovine Leptospirosis, *Leptospira Pomona Infection*

LANGHAM, ROBERT F.; ERSKINE V. MORSE AND RAYMOND L. MORTER

Jour. of Infectious Diseases 103:285-290. 1958. (Journal Article 2270 from the Michigan Agricultural Experiment Station)

1. L. pomona infections were produced in 10 lambs, 8 by artificial inoculation and 2 by natural transmission.
2. The most extensive lesions were observed in the kidneys. There were macroscopic grayish-white circumscribed foci and streaks measuring from 1 to 4 millimeters in diameter. Microscopically these areas were characterized by infiltrations of lymphocytes, some plasma cells, and a few macrophages.
3. The central nervous system of 5 lambs showed one or more of the following: lymphocytic infiltration in meninges and brain, hemorrhage, new capillary formation, and focal increase of microglial and oligodendroglial cells.

A Laboratory "Use Test" for Comparing the Cleanability of Various Materials

KAUFMANN, O. W.

Jour. of Milk and Food Tech. 22:35-36. 1959. (Journal Article 2283 from the Michigan Agricultural Experiment Station)

A simple, controlled soiling, washing, sanitizing, and testing procedure is described for comparing the cleanability of various materials with stainless steel. Bacteriological procedures are used to evaluate soil retention. The test is designed to stimulate actual plant soiling, washing and sanitizing operations.

Minimizing Adverse Effects of Major Shifts in Land Use

BARLOWE, RALEIGH

Jour. of Farm Econ. 40:1339-1349. 1958. (Journal Article 2304 from the Michigan Agricultural Experiment Station)

Large areas in the United States are shifting out of agriculture into urban, highway, and other uses. The shifting process is both natural and desirable in most cases; but it does have occasional adverse effects on the interests of individuals, communities, and society-at-large. An effective use of measures for the social direction of land use is needed to minimize these adverse effects. Educational programs; more and better land use planning; judicious exercise of the public police, taxation, eminent domain, spending, and proprietary powers; and positive programs to encourage desired trends in new land developments provide the best means for minimizing the adverse effects often associated with major shifts in land use.

Retention of Fat and Yields of Cottage Cheese Made with Starter Containing Varying Amounts of Butterfat

HARMON, L. G. AND T. I. HEDRICK

Milk Dealer 48:47, 48, 78, 80. 1958. (Journal Article 2318 from the Michigan Agricultural Experiment Station)

Five series of vats of cottage cheese were made with starter prepared from homogenized and nonhomogenized milks containing varying percentages of fat. The amount of fat in the blended mixture of milk and starter originally in the vats varied from 0.176 percent to 0.378 percent. The proportion of the fat retained in the cheese varied from 63.83 percent to 89.89 percent. The average fat content of the washed curd varied from 0.725 percent in the series of vats made with skim milk starter, to 2.189 percent in the series of vats made with homogenized milk starter. The fat content of the whey varied from an average of 0.069 percent in the cheese made with the skim milk starter, to an average of 0.113 percent in the cheese made with the nonhomogenized whole milk starter. The fat losses were lower in the whey from vats set with starter made from homogenized milk than from vats set with starter made from nonhomogenized milk.

The yields varied from 1.80 to 1.87 pounds of cheese (corrected to 21.0 percent total solids) per pound of milk solids and from 0.378 to 0.396 pounds of cheese solids per pound of milk solids. The higher yields were obtained from the cheese made with the starter containing about 2.0 percent fat and the lower yields were from the cheese made with skim milk starter.

The Carbohydrates of Some Glycoproteins of Bovine Milk

THOMPSON, M. P. AND J. R. BRUNNER

Jour. of Dairy Sci. 42:369-370. 1959. (Journal Article 2340 from the Michigan Agricultural Experiment Station)

The presence of carbohydrates in proteins has been recognized for many years. The objective of our studies has been to identify the carbohydrates which are chemically bound to a) the soluble protein fraction of the fat globule membrane, b) the minor protein fraction as reported by Weinstein, and c) the proteose-peptone fraction. Chemical and chromatographic techniques were employed. Of

interest are the concentration ratios; hexosamine: hexose: fucose: sialic acid. These relationships for the soluble membrane protein, the Weinstein fraction and the proteose-peptone fraction are 1:2.5:0.65:1.8; 1:3.2:0.44:3.4 and 1:2.5:0.61:1.7, respectively. Chromatographic analysis indicated the presence of fucose, galactosamine (weak), galactose, glucosamine, mannose, and sialic acid in the three protein fractions studied.

Gibberellin Effects on Photoperiod-Controlled Growth of Weigela

BUKOVAC, M. J. AND HAROLD DAVIDSON

Nature 183:59-60. 1959. (Journal Article 2349 from the Michigan Agricultural Experiment Station)

Gibberellin (foliar spray 50 p.p.m.) applied to *Weigela* c. 'Vanicek' grown at a 9-hour photoperiod resulted in continued vegetative extension, whereas, non-gibberellin treated plants ceased vegetative elongation and formed rosettes after three weeks. Dormancy, induced by short photoperiods, was broken, and growth rates in excess of those in the non-gibberellin treated plants grown at an 18-hour photoperiod were established. Shoot growth, eight weeks after gibberellin treatment, at the 18-hour photoperiod, exceeded that of the non-treated plants by 63 percent. The gibberellin-promoted increase in shoot extension, at the 18-hour photoperiod, was primarily attributed to an increase in internodal length, while at the 9-hour photoperiod, both internodal length and the number of nodes were increased.

Fungicidal Control of Botrytis Leaf Rot of Hothouse Rhubarb

MURAKISHI, HARRY H. AND HOWARD S. POTTER

Plant Disease Reporter 42:1316-1318. 1958. (Journal Article 2350 from the Michigan Agricultural Experiment Station)

Botrytis leaf rot, the most serious problem of hothouse rhubarb in Michigan, was successfully controlled in two commercial houses in Macomb county by weekly applications of fungicides. On the basis of degree of control and appearance of the leaves and stalks after spraying, Captan was judged the best of 7 fungicides tested. Excellent results were obtained with Phaltan and Thylate also but visible residue caused by the former was judged objectionable. Captan, which is so far the only fungicide approved by the Federal Drug Administration for use on rhubarb, reduced leaf rot from 30 percent in the unsprayed to 3 percent in the sprayed plots of one house. In the second house, disease was reduced from 12 percent to 2 percent.

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